AN EXPLORATION OF THE IMPACT OF SELF-CONTAINED BREATHING APPARATUS TASKS UPON THE COGNITION, PHYSIOLOGY, AND COPING STRATEGIES OF ENGLISH FIREFIGHTERS DURING STRUCTURAL FIRES

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ABSTRACT

Firefighting operations are characterised by high time pressures, a high degree of task and environment uncertainty, life-or-death situations, and the continuous emergence of novel events. Despite this, the factors considered most demanding to firefighters and the strategies that lead to effective management of physiological and psychological stressors at the fire scene are yet to be fully understood.

To address this issue, study 1 utilised a qualitative approach employing a series of focus groups and individual interviews to establish the operational tasks considered to be most demanding by firefighters. Results showed that stressors could be classified into five higher order categories dominated by the physical demands of wearing self-contained breathing apparatus (SCBA) and firefighting activities. Coping responses were grouped by problem-focused and emotion-focused techniques (Lazarus and Folkman, 1984), and also considered coping strategies at early, mid and late career stages. Study 2 utilised a longitudinal approach to examine the development of SCBA specific coping strategies with trainee firefighters over a 12-month period. Stressors were characterised by five higher-order stressors present throughout, and the firefighters reported high levels of control over the task and satisfaction with their performance despite task severity. Study 3 consisted of data collection undertaken during a series of commonly encountered SCBA tasks, including a comparison of novice and experienced firefighters during a single live firefighting task, and experienced firefighters undertaking a series of frequently encountered SCBA tasks. Results found that there were significant changes in cardiovascular and psychological responses of both novice and experienced firefighters following a live firefighting task. There was also a series of significant responses in experienced personnel completing concurrent guideline, search and rescue, and live firefighting tasks. The final study (study 4) considered the demands of SCBA from a command and control perspective. Incorporating a purpose-built incident command suite, the task was found to require high levels of mental and temporal demand but minimal levels of physical demand or frustration. Of the four roles examined, the incident commanders displayed highest levels of task demands, stress, and state anxiety.

The programme of work in this thesis highlights the complex environments firefighters face, the importance of on-scene coping techniques, and the methodological difficulties involved when attempting to capture and analyse data within this population.

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Thank you all.

AUTHOR DECLARATION

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the School Ethics Committee.

Name:

Signature:

Date:

Chapter 1
Introduction

> "A common trait in emergency personnel is that they are action oriented. They can make quick decisions under pressure. They are risk takers and become easily bored. They are more interested in details and they pride themselves on a perfect job. This attention to detail and the perfect job well done sets them up for the stress associated with a failure to achieve unusually high expectations"
>
> Berger (2002, p.7)

Chapter 1 - Introduction

Firefighting remains a hazardous occupation, where unlike in most other jobs, the primary function is one of hazard engagement complicated by extreme time pressure (Kunadharaju et al., 2011), a likelihood of experiencing elevated stress levels, a high degree of task and environment uncertainty, and the continuous emergence of novel events (Sommer & Nja, 2011). The broad scope of this research is to increase firefighter well-being during the acute stages of an emergency incident where each of these factors may be present. To put firefighter risk into numerical perspective, in the US, where there are currently 1.1 million career and volunteer firefighters, each year more than 100 firefighters die in the line of duty and over 80,000 are injured (Karter & Molis, 2008), with the US bureau of labour statistics reporting 1,006 line of duty deaths from 1995-2005. In the UK, there are 58 Fire and Rescue Services attending almost 800,000 incidents per year in England alone (Operational Statistics Bulletin for England 2007/8; 2008). Since 2003, at least 22 UK firefighters have died while on duty, with at least 13 of these killed at fires, the worst 5- year period for more than 30 years. On average, this means that there has been an average of four firefighter deaths per year, or approximately one on-duty death every three months for the last 30 years in the UK (Fire Brigades Union, 2008).

Weston (2012) describes how it is intuitively interesting to learn about the stressors faced, coping strategies employed, the successes, and the fatal failures by people performing actively in extreme environments. The specific environments that firefighters are required to work in presents a unique challenge to performance and goal attainment at an incident, yet despite this, the factors considered most demanding to firefighters and the strategies that lead to effective management of physiological and psychological stressors at the fire scene are yet to be fully understood. Moore-Merrell et al. (2008) state that academic interest in firefighters' occupational risks and hazards has increased in recent years, but many of these studies have analysed factors outside the context of fireground incidents and individuals' past experience at training exercises, whilst the majority of academic firefighter studies have examined highly localised sample populations making broad generalisation of findings difficult (Austin 2001).

In brief, firefighters will be turned out with their crew and will encounter a unique and novel environment placing an acute and often extreme range of psychological and physiological demands upon them. Coping strategies may be utilised, and these must be performed quickly and potentially sustained for the duration of an incident, although at this stage the exact duration of the incident is unlikely to be known. Following the potential implementation of coping strategies to facilitate the management of stressors, depending upon the appraisal of the outcome by the firefighter, they will either consider themselves to have dealt with the demands of the incident, or failed to have utilised resources at their disposal, including effective coping strategies.

This thesis aims to consider the specific components of coping strategies used by firefighters to facilitate successful performance in training exercises and operational incidents, in particular in response to the acute stressors associated with the wearing of self-contained breathing apparatus (SCBA), and the tasks that are likely to require this protective equipment to be worn. The literature review that follows attempts to address the current range of understanding within the fields of firefighting and broader emergency services research. Where these areas have yet to be investigated, investigations are sought from sport psychology and applied military research, in particular when attempting to conceptualise performance, coping, and the relationship between physical demand and cognition.

1.1 Thesis aims

The primary aim of this thesis is to increase firefighter well-being by addressing the physiological impact, cognitive demands, and coping strategies of firefighters when wearing self-contained breathing apparatus (SCBA) in structural fires that include residential dwellings, commercial properties, and large scale industrial units. This will be achieved through research into the specific tasks that necessitate the use of SCBA and the resulting physiological and psychological responses experienced by the firefighter in these environments. Through an understanding of the impact of specific SCBA tasks and conditions, and by exploring the successful coping strategies used by experienced firefighters to manage these demands, it is hoped that recommendations for educational strategies and optimal training environments can be developed.

In order to achieve this overall aim, a number of key objectives have been developed and identified utilising research gaps and a critique of existing firefighter, athlete, and military research provided in the review of the literature in chapter 2:

1. What are the specific on-duty stressors considered most demanding by UK firefighters?

2. What are the techniques used by firefighters to cope during exposure to acute stressors present on the fire scene?
3. How do the coping strategies used at SCBA specific incidents develop?
4. What are the physiological and psychological responses of novice and experienced firefighters undertaking firefighting and SCBA tasks?
5. To investigate the patterns of stress reactivity during the command and control of large scale incidents that requires the use of SCBA.

Chapter 2
Literature review

“From the beginning, emphasis was on people, not fire. It was about ‘peopling’ fires, not on fire suppression. With the former, we organise trained people to perform a task safely and efficiently, and the relevant task is fire suppression. In the latter we suppress fire using people. Historically, this has led to overemphasising the fire and de-emphasising and devaluing the firefighter. We have spent millions on fire research but little on firefighter research. We have many fire researchers. We have no firefighter researchers.”

Putnam (1996, p.3)

Chapter 2 – Literature review

This review of the current firefighting literature is divided into three sections; the initial section introduces the roles and watch structure of the fire and rescue service in the UK, including the legislation that guides the activities firefighters carry out, and the skills and attributes considered by serving firefighters and academic researchers to facilitate elite performance at incidents. The second section establishes the demands of firefighting activities before focusing specifically upon self-contained breathing apparatus (SCBA). Due to the large number of factors that may be present, this section is further categorised into physiological and psychological facets, which in turn are further sub-categorised. Finally, the third section of this chapter provides the rationale for undertaking the research by looking at trends and current figures for firefighter line of duty injuries and deaths in both the UK and US, and the typical contexts that these occur. The direct and indirect costs of the continuation of the high numbers of injury and fatal injuries to firefighters are also considered in greater detail.

2.1 An overview of the fire and rescue service in the UK

2.1.1 Fire service legislation in the UK

The dominant piece of legislation that enables the UK's fire and rescue services to respond to the multitude of tasks is the Fire and Rescue Services Act of 2004 that was introduced to replace the previous Fire Services Act of 1974. The role of this 2004 act is to recognise the broader role undertaken by UK fire and rescue services in the past 50 years, and to represent the firefighters' duties that extend beyond firefighting. Hood (2011) describes how the role of the firefighter in the modern fire and rescue service has become increasingly diverse. In addition to responding to fire-related emergencies and reducing the number of deaths, injuries, and property damage caused by fire, the firefighter must also engage in emergency planning and response to accidents. These incidents are also likely to encompass road, rail and air crashes; coastal pollution; severe floods; terrorist attacks; chemical, biological and radiological incidents. Finally, they must also be trained to rescue people who are trapped in buildings and lifts.

2.1.2 Response to fires

Despite the diverse range of tasks a firefighter undertakes at incidents, the specific acts of 'firefighting' and 'fire extinguishment' still take a predominant role within the response of fire and rescue services nationally. For example, national figures from 2007/8 state that of the incidents attended by fire services in England, around 37% of all were fire-related (Operational Statistics Bulletin for England 2007/8; 2008). As an economic cost, and by considering factors such as healthcare costs, lost output, and emotional and physical suffering, the Office of the Deputy Prime Minister (2004) has estimated that the cost of each fatality in a fire is £1,375,000; whilst responding to fires costs the UK fire service approximately 1.74 billion pounds per year. Therefore a well-trained and rapid responding fire and rescue service has a large number of benefits that includes a significant financial aspect to the taxpayer.

2.1.3 Structure and hierarchy of the fire and rescue service

2.1.3.1 Firefighters within the overall command model of the fire service

In the UK, the 'gold, silver and bronze' model of command and control is routinely used by members of the emergency services to deal with major incidents. Tiers of a joint, multi-agency response to incidents require emergency management, and this system constitutes a nationally agreed framework that allows plans, procedures, roles and responsibilities between agencies to be understood and integrated. Arbuthnot (2008), utilising the Civil Contingencies Act (2004), classifies these three command areas as 'operational', 'tactical' and 'strategic' levels, although in 2004 the UK's Chief Fire Officers Association lobbied successfully to have the terms 'gold', 'silver' and 'bronze' retained alongside 'operational, tactical or strategic' command. Within the model, each strand represents the role and actions of key decision makers at an incident, from firefighters up to Chief Fire Officers:

i. The 'bronze' or 'operational' level is characterised by the work undertaken at the scene of operations at task level, and is typically carried out by individuals or crews supervised by bronze commanders who in turn direct and control the teams to achieve the objectives set by silver command.
ii. 'Silver' or 'tactical' commanders assume the role of the overall running of the incident on the incident ground. Their role is also to ensure that operational levels and sectors designated are supported for maximum effectiveness through tactical co-ordination and overview of operations on the ground, as well as through allocation of resources, determination of priorities and inter-agency liaison. Silver level commanders also need to

decide whether there is a need for gold command if not already in place, although it is possible for an incident to be structured up to silver command level without gold level being necessary.

iii. Finally, ‘gold’ or ‘strategic’ command is used in the most serious of situations such as those where the event could have a significant impact upon resources, the wider community or the organization’s reputation, or where a large number of agencies are likely to be involved in an incident over an extended duration. Typically, for gold command to take place the incident will be considered unusually large, protracted or catastrophic, and will usually involve the exercise of tactics at a distance away from the scene of the incident with the aim of taking a longer view of the situation.

As the ‘bronze’ command level typically consists of firefighters, supervisory managers and sector commanders at an operational level, this thesis is considered to be most applicable applicable to those operating primarily within the ‘bronze’ level within this command structure. However, potential benefits to personnel within ‘gold’ and ‘silver’ command roles are also discussed later in this thesis.

2.1.3.2 Station and watch structure

Fire stations are purpose built structures that allow the firefighters working there to be self-sufficient for 24 hours a day, 365 days per year. These buildings feature (amongst other fire brigade specific specifications) an appliance bay (garage for the fire engines), fire house and yard (for training and practice drills), office, lecture room, canteen, locker room and rest area. Each watch and each station will have a specific officer-in-charge (OiC); an officer above the rank of firefighter who rides on the fire appliance and is responsible for taking charge at operational incidents, as well as organising the day-to-day running of the watch through planning of their training, welfare and administrative duties.

Wholetime (or full-time) watches include firefighters who work on a continuous and full-time basis, observing minimum staffing levels to ensure sufficient personnel are available for the required fire appliances at the station (currently a minimum of four personnel per fire appliance, including at least one crew commander). The call-out to operational incidents can be provided in a number of ways. This can include the control room dispatching fire appliances through an auditory turnout system on station and corresponding printed turnout sheet (providing details of the appliances required and the address of the incident), or directly via radio contact to the appliance away from the station around their allocated geographical area, and as such there is often very limited information up to the point of arrival at the incident scene. This latter method can also be incorporated when the fire appliance is returning back to the station from another incident, or even include redeployment to another incident whilst en-route to a different incident. Other operational members of the fire service may also work in 'day-staffed' stations whereby firefighters cover the station during the day and are 'on-call' at night and on weekends, or at 'retained' stations where firefighters hold down a 'regular' civilian job and are called to an incident via a pager worn on the person. In this latter work shift, the retained / on-call firefighter will immediately leave their place of work (or home) and proceed to their fire station where they will change into appropriate personal protective equipment (PPE) and board the fire appliance to respond to an emergency call.

2.1.3.3 Scope

There are currently 58 fire and rescue services (FRS) in the UK established by stature, as well as many other employers. According to the latest figures, as of August 2011 the fire and rescue response in England consisted of 46 FRS. There are a further eight FRS in Scotland; three in Wales; a single FRS in Northern Ireland divided into four districts; services in the Crown Dependencies of Jersey, Guernsey, and the Isle of Man; and the Ministry of Defence's Defence Fire Risk Management Organisation (such as the Royal Navy Firefighting Training Centre). Private sectors employing firefighters also include Airport FRS, Port Fire Services, Industrial Fire Services (such as those in chemical, pharmaceutical, oil, gas, and nuclear industries), and those in specialist private sector firms (Hood, 2011).

There are over 71,000 personnel currently working in the FRS sector in the UK (Hood, 2011). Skills for Justice in 2007-2008, describe how 81% of the current UK FRS workforce is located in England, 12% are based in Scotland, 4% in Wales, whilst Northern Ireland compromises 3% of staff. In England alone, there are 50,943 members of staff consisting of 29,062 wholetime firefighters, 12,140 retained firefighters, and 1,477 control room personnel responsible for dispatch and receiving emergency calls employed (Hood, 2011). Of these firefighters listed above, 95.9% are males, with a further 4.1% female; 86.8% describe themselves to be 'white', 3.6% consider themselves to be part of an ethnic minority, and a further 10% did not state an ethnicity.

2.1.3.4 Firefighter attributes

Firefighters must ensure they possess a unique set of skills and attributes to successfully attend to all tasks that may be required of them, which includes a combination of both physical and psychologically based attributes. Research in the UK by the Department of Communities and Local Government (2008) surveyed current and ex-firefighters about the skills needed to be a firefighter, and found responses to be similar regardless of the gender or age of the respondent. In total, 98% of respondents stated that they ‘strongly agree’ or ‘agreed’ that the ability to work in a team was important, closely followed by good decision making (94%), self-discipline (94%), and problem solving (91%). Other qualities included manual dexterity (90%) and physical strength (89%), as well as personality attributes such as a sense of humour (79%) and being brave (52%). Whilst there is a significant emphasis placed upon the ability of a firefighter to show emotional control and restraint at an emergency scene (Thurnell-Read & Parker, 2008), in order to meet the demands of the role, firefighters must also possess high levels of muscular, anaerobic, and aerobic fitness and have a favourable body composition (Barr et al., 2010).

Firefighters must also be able to work effectively under high time pressure, or face potentially serious consequences. Findings from Rosmuller and Ale (2008), reviewing Dutch firefighter fatalities that occurred during fire extinguishing activities, found that 71% of the deaths occurred during situations of high time pressure, in particular in situations of high time pressure with no life to be rescued (62%). Finally, through experience at a wide range of operational incidents and training environments, a firefighter must also develop what Lloyd and Somerville (2006) have termed ‘fire sense’ where firefighters listen to their bodies and draw information cues from them (these cues can for instance be the loudness of a fire, the colour of smoke, or the amount of heat produced) to assist with their performance and safety at an incident.

2.2 The demands of wearing a self-contained breathing apparatus (SCBA) during firefighting activities

The implementation of a firefighter’s skills and attributes to specific situations is yet to be fully understood due in part to the rarity of a ‘typical’ or ‘routine’ day on shift by a firefighter and the associated demands and responsibilities of each task. However, despite the wide range of work undertaken by the FRS in the UK, Rayson et al. (2005) have identified that the majority of tasks undertaken by firefighters will be characterised by actions that include walking, crawling, climbing, lifting, lowering, and carrying, and typically incorporate ladders, hose, water pumps, and SCBA. Rayson et al. (2005) have also stated that the majority of tasks utilised within firefighter research include variations of the following:

- Ladder manipulations (such as carrying, raising and lowering the ladder)
- Stair climbing
- Hose running, dragging and operating
- Casualty search and rescue
- Victim/dummy carry
- Hot house operations in personal protective equipment including SCBA
- Overhaul (damping down after firefighting operations)
- Pike/Halligan tool operations
- Chopping operations.

When undertaking these tasks, there is the potential for firefighters to be exposed to heat. Because of this likelihood of encountering high temperatures during a working day, Foster and Roberts (1994) have classified the heat conditions that firefighters are likely to be exposed to into four categories and include the recommended time limits that firefighters work in each of the conditions:

- 'Routine' conditions. These are considered to exist in the majority of operational incidents encountered by firefighters and have been proposed to have a time limit of 25 minutes when working in temperatures of 100^{o}C.
- 'Hazard' conditions. This includes the environmental conditions when working outside of a building where there are extreme temperatures and radiant heat flux, and are considered to have an operating time limit of around one minute at 160^{o}C.
- 'Extreme' and 'critical' conditions. These environmental conditions are considered to be greater than those for 'hazardous' but do not exceed 235^{o} C and can be tolerated for around one minute. However, due to the unacceptable level of damage that may occur to equipment and personal protective equipment, Foster and Roberts (2004) state that these conditions

would be too dangerous for firefighters to operate under and would put them at risk.

- ‘Critical’ conditions. These conditions are considered to be life threatening and firefighters would not be expected to operate or persevere under such conditions.

To operate effectively in conditions of heat and smoke, one of the key roles firefighters must be able to undertake is the correct and effective usage of self-contained breathing apparatus (SCBA), with an example of the key parts of this equipment displayed in figure 2.1.

Figure 2.1. Example of a self-contained breathing apparatus (SCBA) set, complete with compressed air cylinder, ergonomically designed backplate, full face mask, and pressure gauge (www.cardinalsafetysupply.com)

The use of SCBA represents a compromise for the firefighter as it will act as a significant barrier to performance due to its weight and ergonomic factors yet provides an essential component of safety by allowing the individual to operate in fire, heat, and irrespirable atmospheres. The factors enabling firefighters to be able to perform at optimal levels whilst wearing SCBA are still to be fully understood, despite this equipment being routinely incorporated during activities that include rescuing life, smoke ventilation, fire suppression, salvage, and overhaul tasks. During incidents where there is a presence of smoke at fires, SCBA will also protect the wearer from exposure to hazardous chemical contaminants found to be present including acrolein, benzene, methylene chloride, polyaromatic hydrocarbons, perchloroethylene, toluene, trichloroethylene, trichlorophenol, xylene, formaldehyde, and other gases described by Austin et al.

(2001) as being of immediate concern to human health due to their acute and toxic effects.

2.2.1 SCBA demands and usage

Firefighters are expected to work in teams during SCBA tasks, and therefore the working duration of a SCBA team will only last as long as its weakest member, with these teams typically determined at the start of a shift during roll-call by the OiC of the duty watch. Therefore, firefighters entering an inhospitable atmosphere must have an awareness of the capabilities and limitations of their equipment, as well as the impact SCBA equipment may have upon their performance and physiological capabilities.

Before any tasks are undertaken, simply donning and wearing SCBA presents an ergonomic challenge for the individual. Prior to the introduction of other environmental factors at the incident it has been determined that while wearing SCBA the heart rate of a firefighter may rise to near maximal levels for periods averaging 12-14 minutes (Pearson et al., 1995).Typical SCBA equipment displayed in figure 2.1 weighs between 10 and 12 kg, with the majority of this mass localised on the back (Cheung et al., 2010), whilst Marshall (2003) estimates the total weight of personal protective equipment and SCBA to be around 50 pounds (almost 23 kilograms) per person. This added bulk limits the ability of the wearer to fit into small spaces, as well as affecting flexibility and movement due to a change in the individual’s centre of gravity. This will not include the weight and ergonomic challenges of supplementary equipment that is often required at the incident and will often include hose, breaking in gear (such as axes and large sledge-hammers), first aid equipment, and the additional energy cost of complex movements that include moving quickly upstairs and through confined spaces. Research by Gledhill and Jamnik (1992) reported that the weight of firefighting tools and equipment can often be greater than the mass of the SCBA and PPE, further increasing the metabolic load on the firefighter. Furthermore, Rayson et al. (2005), using experienced firefighters, found that firefighters’ SCBA equipment and supplementary equipment created an external load equivalent to 30% of the mean body mass of the group they were studying, including the lightest firefighter in the sample who had to carry a load equivalent to 41% of their own body mass.

SCBA can also limit the normal sensory awareness abilities of a firefighter, including scent, hearing and sight, whilst clear verbal communications are made more difficult. SCBA does not provide the firefighter with particularly long durations of breathable air, and running out of air during a task presents a life-threatening risk to firefighters. The compressed air cylinder attached to a SCBA set varies, with different models stated as lasting for a minimum of 30, 45, 50, and 60 minutes duration, whilst extended-duration SCBA is also available that provides up to 120 minutes of compressed air usage. However, although these durations have been developed and based upon laboratory conditions, in firefighting situations, cylinder durations are usually less than those stated on the equipment, and generally have a useful realistic life of around 50% of the rated time (Johnson et al., 2004). The presence of an auditory low pressure warning whistle is often attached as a safety measure of a SCBA set, and indicates to the wearer that there is around 20-25% of the air left in the cylinder. The time taken before this whistle actuates varies amongst individuals, and the actual 'working' duration of a cylinder is subject to a number of factors. For example, better cardiovascular condition can extend the duration, whilst poor levels can reduce it. In addition, emotions such as panic or anxiety can also reduce the duration of the cylinder due to increased breathing and respiration rate (Sendelbach, 2001).

Although the usage of SCBA is very much dependent upon the exact task being encountered, it is likely that it will be utilised to enter a structural fire, following heavy smoke-logging, and under a chemical protection / gas tight suit (Young, 2007), although it is not always a mandatory part of personal protective equipment at fires. For example, the 906 firefighters of the City of Montreal were found to require their SCBA for over 50% of structural fires but only for around 6% of the total time spent at all fires (Austin et al., 2001), whilst a study of Finnish firefighters found that operational firefighters only performed maximal rescue tasks in SCBA around four times per year (Lusa et al., 1993). In the UK, researchers have suggested that firefighters wear SCBA less than once per week and that as a result firefighters probably do not develop or maintain any specific physiological tolerances to SCBA wearing (Love et al., 1994).

2.3 The 'dual stress' demands of firefighting whilst wearing SCBA

Studies examining the effects of SCBA in firefighters have typically considered either the physiological or psychological demands placed upon the individual, despite the likelihood that both are present and may interact with each other. The presence of 'dual stress' conditions is considered to be a combination of both physiological and psychological demands, and is thought to exist in firefighters, law enforcement, armed forces and health care personnel (Webb at al. 2011). Marshall (2003) has described how the 'dual-stress' condition can manifest during a SCBA wear, leading to an excess of physical and mental fatigue in the firefighter which can present a tremendous amount of potential hazards. As fatigue sets in, concentration has the potential to decrease, resulting in a reduction in judgment that could put the firefighter at risk. In addition, increases in physical fatigue created by climbing ladders, maintaining balance, and carrying out a rescue could pose potential hazards for the individual as well as the person(s) they are trying to rescue due to an impact upon cognitive facets (Marshall, 2003).

The interactions between the physiological and psychological demands of SCBA tasks have yet to be investigated and understood. Therefore, the current body of literature can be broadly split into two distinct fields as either physiological reactivity during SCBA demands, or the psychological responses of an individual to SCBA tasks. Each of these areas and their key components are presented in further detail.

2.4 The physiological demands of wearing SCBA during firefighting activities

The physical work undertaken by firefighters is described by the United States Fire Administration (USFA) (2007) to be one of the most physically demanding activities that the human body can be required to perform. Firefighting activities will often require the firefighter to work at or near maximal capacity for several minutes at a time to meet the requirements of an incident and ensure a successful outcome (Mier & Gibson, 2004), and is required immediately and following an abrupt change from rest. As a result, Rowell (1993) describes how probably the greatest stress ever imposed on the human cardiovascular system (except for severe haemorrhage) is the combination of exercise and hyperthermia. When involved together these stresses are capable of inducing a life-threatening challenge to the individual, especially those who drive themselves to extremes in hot environments. Smith et al. (2001) describe how in addition to thermal strain, firefighting places considerable strain on the cardiovascular system primarily because of the competing demands for blood flow to the metabolically active muscles to support heavy muscular work and the skin in response to the thermoregulatory demands resulting from muscular work in a hot environment.

Advances in the availability and capacity of more in-depth physiological testing equipment now make advanced methodologies widely available. Unlike in previous studies that have measured air management through early methods of gas collection in bags for later analysis (Lemon & Hermiston, 1977), recent methods such as those utilised by Williams-Bell et al. (2010) are now available to measure a variety of outputs directly from the SCBA including air consumption, oxygen uptake, carbon dioxide output and respiratory exchange ratio. The result is that the data gathered in this way is capable of providing a new insight into the physiological stress of firefighting under conditions that replicate the actual SCBA situation as closely as possible. However, due to the individual differences between firefighters, including shift duration, exposure to fires at real life incidents, and the duration of previous SCBA tasks, measuring and identifying the specific changes in cardiovascular reactivity is still acknowledged as a difficult area to measure and assess (Rayson et al., 2005). Based upon a review of the literature, the key factors affecting physiological function have been identified and classified into five main areas as displayed in figure 2.2 and are described in further detail.

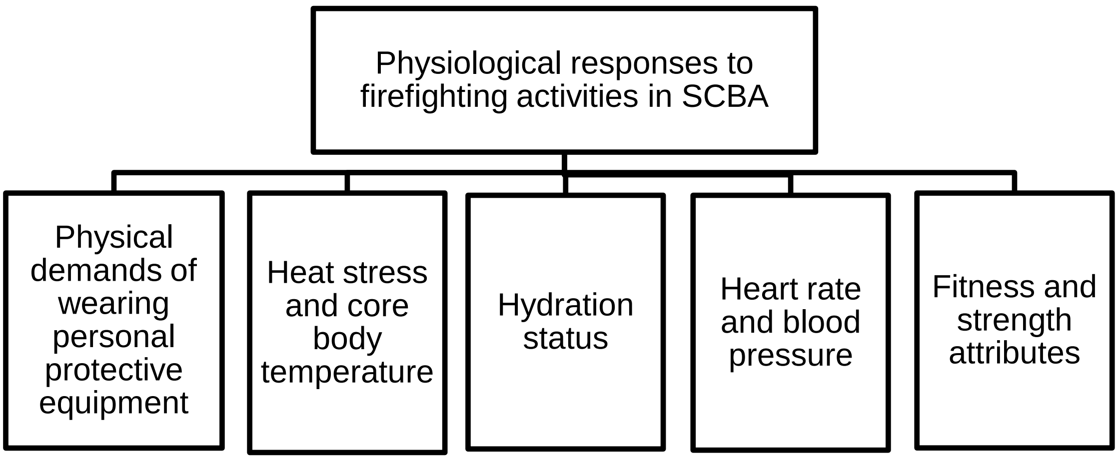

Figure 2.2. Factors affecting physiological function associated with firefighters' performance whilst wearing SCBA

2.4.1 Physical demands of wearing personal protective equipment (PPE)

As a matter of health and safety, all firefighters in the UK are supplied with personal protective equipment (PPE). This clothing must be suitable to prevent injuries and hazards from thermal (flame, radiant and convective heat), physical (impact, debris, and rough surfaces), biological (blood borne pathogens), environmental (ambient temperature and humidity extremes), and chemical (skin contact) sources. This PPE is typically thick, heavy and extremely durable, and although this multitude of layers in the clothing acts as a permeable barrier to water and other chemicals, the result is a potential impact upon firefighter performance due to decreased mobility and increased muscular strain (Cheung et al., 2010). In the UK, a firefighter's PPE will typically consist of impermeable firefighting boots, tunic, overtrousers, helmet, impermeable gloves, and flashhood (worn over the head to protect the neck and ears). In addition, depending on the incident, self-contained breathing apparatus (SCBA), gas tight or chemical protection suits, high visibility surcoats, eye protection, breathing respirators or ear-protectors may also be worn and impact upon the individuals normal senses.

As a result, firefighting PPE not only acts as a barrier to external heat but also impairs heat loss by inhibiting evaporation of sweat (Goldman, 1990), leading to a metabolic cost that decreases the time for firefighters to reach fatigue. It is estimated that PPE and the addition of SCBA adds to the energy cost of any work undertaken, resulting in work classified as 'low' becoming 'high' and work classified as 'moderate' being reclassified as 'very high' by the individual. For example, in a fifteen minute treadmill walking task, firefighters in full PPE and breathing apparatus demonstrated raises in heart rate by an average of 50 bpm compared to the same task in station uniform, and was also found to lead to a rise in core temperature. Compared to wearing shorts and t-shirts, UK firefighters wearing fire kit without SCBA undertaking a treadmill based task increased oxygen consumption by between 10% (Baker et al., 2000) and 15-20% (Gravelling et al., 1999), with an similar additive increase again with SCBA added, or an increased energy output of 33% (Sykes, 1993). Further research has demonstrated that 50 minutes on a treadmill task when wearing PPE in a heated room can lead to a 1.1kg loss in body mass, and a rise in core body temperature that may not return to baseline levels until 2 hours after completion of the task (Beauchamp, 2010). When undertaking 18 minutes of two minute work-rest cycles involving stair climbing, simulated forcible entry tests and a simulated search and simulated hose advance, the effects of wearing PPE have been considered to be more detrimental to firefighters' ability to make a safe obstacle crossing than the effects of fatigue (Smith et al., 2008).

In comparison to standard sports clothing, firefighting PPE has also been found to reduce an individual's range of motion (ROM) by 26% at the ankle and 38%

at the neck (Coca et al., 2010), with important implications for on-the-job mobility and peripheral vision, as well as causing significant reductions in knee ROM when crawling or stepping up (Dorman, 2007). Balance may also be affected, with research demonstrating how older firefighters' balance was more strongly affected by PPE than younger firefighters (Smith, Horn & Haigh, 2008). PPE has also been shown to significantly affect firefighters' gait performance, suggesting that firefighters' gait cycle will be significantly modified simply by donning PPE, which may lead to increased risk of injury on account of forced changes in their biomechanics at any incident requiring PPE, not just during firefighting tasks (Smith et al., 2008). However, it must also be noted that PPE also leads to increased confidence and protection that can facilitate improved performance of firefighters in certain tasks. For example, Coca et al. (2010) found that in a one arm search task performed on the knees, participants performed the task over 9 seconds faster and took three strides less to cover the same distance due to greater protection afforded to their knees in firefighting PPE regardless of increased energy expenditure.

2.4.2 Heat stress and core-body temperature

Capacity of an individual to conduct work in high temperatures is considered to be significantly reduced in comparison to carrying out work in cooler conditions (Galloway, 1997). However, it is important that high temperatures are not considered to be the sole component of heat strain or heat stress in firefighters, with Barr et al. (2010) stating that physiological strain can result from a number of factors and that endogenous heat production is capable of imposing heat strain during strenuous tasks even in the absence of high environmental temperatures. In the FRS, the temperature of working conditions for personnel are likely to be raised due to a number of components including wearing of PPE and respiratory protective equipment, the ambient temperature at the scene of operations, and the duration of any work undertaken at the scene. Due to the limited vapour permeability of firefighters PPE, and the added metabolic heat production resulting from the increased weight impact on the thermoregulatory system by reducing the ability to dissipate generated heat, there is often continued heat storage in the body (Cheung et al., 2010) that can raise a firefighter's internal (core body) temperature.

Studies investigating the core body temperature of firefighters have typically reported core temperature values of 39-41^{o} C (e.g. Smith et al. 1997), yet if core body temperature was to exceed 40^{o} C, heat stroke can occur and present a life-threatening disorder to the individual that requires immediate medical attention (Meldrum, 2004). In addition, excessive core body temperature can also limit the duration of work that can be undertaken without rest or recuperation (Meldrum, 2004).

Meldrum (2004) has stated that increases in core body temperature during firefighting specific tasks are not uncommon, and the need for both the firefighters and their commanding officers to identify the symptoms of heat disorders can be considered a critical component of scene safety. These particular symptoms have been identified by Meldrum (2004) as including:

- A feeling of being unwell, including nausea, tiredness, headaches, dizziness and vomiting
- Breathing difficulties or shallow rapid respiration
- A rapid pulse that may be bounding or weak
- Muscle cramps
- Poor control over movements, such as stumbling or weakness
- Irritability

When undertaking firefighting search and rescue tasks, Rayson et al. (2005) state that heat strain is the single greatest source of performance limitation and physiological threat to firefighter well-being. Furthermore, firefighters repeatedly exposed to heat stress are also at risk of heat illness when coupled with the increased threat of fatigue (Carter et al., 2007). It has been found in a number of sporting and occupational disciplines that heat stress can be a contributor to significant performance degradation, and may be present during firefighting exercises of longer duration. This may lead to decreased plasma volume, dehydration, fatigue, disorientation, and impaired cognitive function (FEMA, 2008), all of which present a threat to firefighter safety, particularly during SCBA tasks. As well as firefighting activities, further physical activities that may lead to excessive core temperature include strenuous work in gas tight suits, dealing with excessive grassland fires, and providing fireground support (such as the provision of water supplies over long or difficult terrain) (Meldrum, 2004).

Researchers such as Rossi (2003) have reported that specific core temperature changes during tasks, such as around 15 minutes of firefighting activities in a training facility increasing core body temperature an average of 1.0°C in recruit firefighters, and increases in core body temperatures in experienced firefighters reported at an average of 0.9°C during SCBA tasks (Angerer et al., 2008).

2.4.3 Hydration status

The hydration status of a firefighter may also play a large part in the successful completion of firefighting tasks. Working in a hot environment, using heavy tools, and wearing PPE all create high quantities of sweat loss, with studies showing firefighters can lose sweat at a rate of between approximately 0.95 litres per hour (Selkirk et al., 2006) or between 0.7 – 2.1 litres per hour at temperatures reaching 190^{o} C (Rossi, 2003).

Fluid loss is an area of firefighting activities that has the potential to lead to an increased risk to firefighters working within a risk area. Studies have shown that dehydration may also be related to a decrease in a number of cognitive abilities such as short-term memory, working memory and visuo-motor abilities (Sharma et al., 1986). Furthermore, the reduction in cognitive performance is often relative to the degree of dehydration, and becomes significant at a 2% body weight loss (Gopinathan et al., 1988). Physically, when 2-4% of total body water is lost aerobic performance may reduce by 20-30% (Nevola, 2008), whilst there is also a drop in tolerance time of individuals when working in uncomfortable conditions compared to euhydrated individuals (Nevola, 2008).

Even during relatively cooler conditions, there is still likely to be a high level of fluid loss in firefighters. In a series of breathing apparatus tasks in conditions of ~24^{o} C, firefighters were found to lose fluid averaging 1.1 litres and sweat loss of 0.6 litres per hour after search and rescue tasks of ~25 minutes duration (Carter et al., 2008). During live fire tasks peaking at 209^{o} C and requiring both an initial deployment and redeployment by the SCBA team there was found to be an average fluid loss of 1.0 litre across both conditions, with sweat loss per person averaging 0.6 litres per hour during tasks of ~18 minutes duration (Carter at al., 2008). The researchers recommend that when working under hot and strenuous conditions, pre-hydration and rehydration needs to be given a high priority to individuals, as well as benefiting from consuming carbohydrates prior to subsequent activity to reduce the impact of post task decreased blood glucose even following 90 minutes of recovery. Similarly, Nevola (2003) recommends that all firefighters be made aware of the effects and symptoms of dehydration, and individuals should be encouraged to consume a 500 ml quantity of water prior to commencing their operational duty.

2.4.4 Heart rate and blood pressure

2.4.4.1 Heart rate

Heart rate measurement has been reported in a wide range of studies that have investigated firefighting and SCBA tasks, and research has consistently demonstrated a significant increase in heart rate during firefighting and SCBA tasks, with both Rayson et al. (2005) and Barr et al. (2010) providing recent literature reviews for UK firefighter populations. In general, during firefighting tasks, firefighters' heart rate levels will go up towards 80 to 90 percent of their maximum and stay there for an extended period of time depending on the level of fitness of the firefighter (Marshall, 2003), with studies demonstrating SCBA tasks to involve near maximal heart rate levels even during short-bouts of firefighting (Smith et al., 2001; 2005).

Research has demonstrated that heart rate measurements are highly dependent upon the type of task undertaken, and as a result there are differences in the temperatures, equipment, procedures and exposure times. Studies rarely use control groups, and at present there is no standardization of SCBA tasks in either training environments or firefighter research. Research has demonstrated that increased temperatures can increase heart rate, such as reported by Rayson et al. (2007), who found an age-predicted maximum heart rate in 69% of their participant sample during a hot fire task, compared to 56% of participants reaching this level in a 'cool' temperature task. Similarly, using an overhauling task at either ambient conditions with no fire (around 59°F) or live fires (around 195°F) Smith et al. (1997) found heart rates to increase by an average of 36 beats per minute in live fire conditions (average of 175 bpm compared to 139 bpm in ambient conditions) suggesting an increased physical demand caused by the greater level of heat.

In terms of specific SCBA tasks, Holmer and Gavhed (2007) state that in a comparison of different firefighting tasks, performing a ceiling overhauling task at 90^{o} C led to a mean heart rate of 175 beats per minute (bpm), or 90% of the participants' age predicted maximum. Alternatively, during a ship firefighting exercise, heart rates of Navy firefighters were found to be highest during a drum-carrying task (88% of maximum heart rate) compared to the lowest heart rate of 77% maximum heart rate during a boundary cooling task (Bilzon et al., 2001), whilst during high-rise exercises, firefighter heart rates were measured at an average of 91 +/- 3% heart rate maximum (Williams-Bell et al., 2010). Similarly, other studies report mean heart rates of firefighters as ranging anywhere from 150 +/- 13 beats per minute during a six floor rescue of hospital patients (Von Heimburg et al., 2006) to 182 +/- 20 bpm during a simulated rescue task after a 40 min live fire training exercise (Elgin & Tipton, 2003) and 182 bpm after live fire drills in a training environment (Smith et al., 1996). Furthermore, during a large simulated fire, 7 of the 49 firefighters taking part in the research of Angerer et al. (2008) actually exceeded their age predicted maximum, suggesting the presence of an extremely high cardiovascular load during a wide range of firefighting tasks.

However, care must be taken when interpreting heart rates, and it is unknown if reported increases are as a result of environmental temperatures, PPE, or due to increases in physical activity and psychological stress. It has been stated that it is unwise to draw heart rate comparisons with other research, with Smith et al. (2001) stating that the differences in heart rates reported by different firefighter research studies are likely attributable to differences in the intensity of the firefighting task and radiant heat load.

In particular, the use of age predicted HR_{max}, such as that used in a number of firefighter studies described above may provide inaccurate findings, as this equation is not considered to be valid for predicting HR_{max} across the adult range in healthy humans. Tanaka et al. (2003) state that age predicted maximal heart rate is limited in a number of ways, including the age-predicted equation originally being determined ‘arbitrarily’ from a total of 10 studies and being independent of gender and physical activity status. Tanaka et al. (2001) further describe how the traditional 220-age equation overestimates HR_{max} in young adults, intersects with the present equation at age 40 years and then increasingly underestimates HR_{max} with further increases in age, limiting the validity of data gathered using this calculation.

2.4.4.2 Blood pressure

During blood pressure measurement, systolic blood pressure (SBP) is defined as the strain placed against the arterial walls during ventricular contraction, whilst diastolic blood pressure (DBP) relates to the peripheral resistance, or ease by which blood flows into the capillaries (Hoffman, 2006). Due to the potential negative implications associated with increased blood pressure (hypertension), a series of strict controls for measuring blood pressure levels of emergency workers exists. In 2007 the National Fire Protection Association published recommended levels for firefighters in the USA of less than 180 mmHg for systolic blood pressure, and lower than 100 mmHg for diastolic blood pressure, with restriction from operational duty recommended when these levels are exceeded.

Kales et al. (2009) has stated that approximately three quarters of emergency responders in the US have elevated blood pressure at a level considered either pre-hypertensive or hypertensive, as measured by resting systolic blood pressure, with the highest readings found in older personnel. Utilising a wide body of previous research, the researchers identified a number of occupational risk factors associated with elevated blood pressure. These include irregular physical exertion and post-traumatic stress disorder, both of which have been found to increase both resting blood pressure and heart rate, and blood pressure reactivity to traumatic stimuli, and can be considered a potential hazard for firefighters (Kales et al., 2009).

Regarding acute blood pressure changes following completion of firefighting exercises, Smith et al. (2008) found that 18 minutes of alternating work-rest firefighting activities led to 10% of participants being classified as hypertensive, whilst a further 65% of participants were considered pre-hypertensive. It is stated that increased cardiac output and the associated increased blood pressure are considered to occur to allow the body to be prepared to meet increased exertional demands of firefighting (Webb et al., 2011). However, in contrast to these increases, Fernhall et al. (2012) have demonstrated that blood pressure in firefighters may even be unaltered following a three hour firefighting task as found in their sample, and is consistent with athlete research of Fahs et al. (2009) who did not find changes in blood pressure 30 minutes after a bout of acute resistance exercise.

Research also suggests that blood pressure may also be affected by a number of other variables in addition to the task being undertaken. For example, noise exposure to alarms, sirens, vehicle engines and mechanical rescue equipment are estimated to produce a typical noise exposure in the 63-85 decibel (dBA) range, consistent intermittent exposures over 90 dBA, and a recorded level of over 100dBA over an 8-hour shift (Kales et al. 2009). Van Kempel et al. (2002) describe how there is an increase of 0.51mmHg in systolic blood pressure per 5 decibel increase in occupational noise exposure relative to an increase of around 5.9-11.8 mmHg attributable solely to exposure to siren noise, although the researchers state that the duration of these effects is still to be agreed. Finally, increased blood pressure may also be present in firefighters due to factors other than the physical or exertional demands of the task, with observations of emergency workers suggesting that high job demands and low flexibility in decision making can lead to individuals experiencing periods of significant increases in systolic blood pressure (Kales et al., 2009). Therefore, the task-specific changes in blood pressure that may occur are yet to be fully understood and further research is recommended.

2.4.5 Fitness and strength attributes

In general, physical fitness describes a state of well-being that enables an individual to meet their daily physical demands with vigour whilst coping with any unforeseen emergencies with the minimum of distress, and with sufficient physical conditioning to make a rapid recovery (Nevola, 2003). This ability to recover also has implications for SCBA tasks, where, during large scale incidents, firefighters may be expected to undertake more than one SCBA wear at the scene of operations. For example, the first SCBA wear of the firefighter's shift may involve the extinguishment of a fire followed by venting the building of smoke and therefore the wears would consist of an initial hot wear followed by a second 'cool' wear. Alternatively, the first wear may instead be one of casualty rescue in smoke logged conditions (relatively cool temperatures) followed by a SCBA wear of fire extinguishment (hot wear), and the impact of this on firefighter performance and physiological parameters is in need of greater examination.

A limited number of studies have attempted to address the issue of physical conditioning and recovery by utilising repeated and concurrent SCBA wears, with the general trend showing an intense and repeated physiological demand after each task. For example, Elgin and Tipton (2003) demonstrated that firefighter instructors are capable of successfully carrying out a rescue task immediately following a 10-minute hot-fire training task that also raised deep body temperature. However, the researchers concluded that due to the closeness to the firefighters' physiological limit, in more severe situations a rescue may not be possible. During multiple repeated SCBA wears involving concurrent challenges, firefighters' heart rates were found to consistently rise, with maximal heart rate occurring in each of the five times that participants were actively taking part in fire suppression activities. This was also found to result in levels of dehydration and hyperthermia throughout the three hours of testing equivalent to levels found in the physiological responses of athletes participating in long distance endurance events (Shave et al., 2008).

Therefore, fitness can be considered to be an essential component of firefighting; whereby the fitter a firefighter is, the more easily they will be able to perform the same duties as an unfit firefighter with less cardiovascular and thermal strain placed on the body (Barr et al., 2010). The product of arterial-venous oxygen difference and the maximum cardiac output, $\dot{V}0_{2max}$ is regarded by exercise professionals as the single best measurement of cardio-respiratory endurance and is accepted as the baseline predictor of endurance performance (Noakes et al., 2001).

Firefighting is considered to have a demand intensity greater than running or cycling exercises that have an equivalent $\dot{V}0_{2max}$ (Williams-Bell et al., 2010), prompting the US the 'Fire Service Joint Labor Management Wellness/Fitness Initiative' to recommend a $\dot{V}0_{2max}$ of at least 42 ml/kg/min in order for a firefighter to adequately meet the aerobic demands of the job. This level is stated to be the minimum standard that allows a firefighter to have a margin of safety and sufficient reserve capacity when carrying out firefighting duties (Davis et al., 1986). In the UK, this figure for firefighters stands at 45 ml/kg/min, although Rayson et al. (2005) have estimated the mean $\dot{V}0_{2max}$ of serving firefighters in the UK to be around 43 ml/kg/min.

The minimum $\dot{V}0_{2max}$ required to safely and effectively complete a SCBA tasks remains open to debate, although Elsner and Kolkhorst (2008) state that firefighters with a lower level of $\dot{V}0_{2max}$ tended to complete a firefighting simulation slower than counterparts with higher levels of $\dot{V}0_{2max}$. For many years the consistent view of firefighters wearing SCBA was that they work at an average of 60-70% $\dot{V}0_{2max}$ at incidents (Williams-Bell et al., 2010), although an investigation of German firefighters undertaking casualty rescue on a simulated sixth floor hospital, has led von Heimburg et al. (2006) to state that since a task lasting between 5 and 9 minutes creates a $\dot{V}0_{2max}$ equivalent to 84% of the participant's maximum, a minimum $\dot{V}0_{2max}$ of 41 ml/kg/min is required by firefighters. Finally, others researchers such as Sothmann et al. (1990) suggest that a lower value of 33.5 ml/kg/min should be the minimum acceptable level to perform firefighting activities.

It should be expected that firefighters, because of the physical demands of the occupation, would be extremely fit individuals, with over 93% of UK firefighters rating themselves as having average or above average fitness levels compared to the general population (Pearson et al., 1995). However, recent research suggests that this may not be the case. For example, Fernhall et al (2012) describe how unlike endurance athletes exposed to extended duration events, their sample of forty male firefighters undertaking prolonged intermittent firefighting activities were not endurance trained and many were overweight or obese. They stated that firefighters in general, tend to be a very different population to those generally participating in endurance events. Roberts et al. (2002) also demonstrated that new US firefighters tended to have poor physical conditioning that could jeopardise their safety during fire suppression activities. Only after a 16-week exercise training programme involving one hour per day, three times per week of exercise, were the firefighters' increases in aerobic capacity and lean body mass considered sufficient for them to be assigned to duty.

Aside from reduced fat and higher $\dot{V}0_{2max}$ levels, improvements in performance can also be predicted from strength measures. Research by Michaelides et al. (2008) has demonstrated that having upper body muscular endurance and upper body strength were significantly related to completion of a number of firefighting tasks including stair climb, hose lift and pull, 82kg mannequin drag, and charged hose advance. Correlations demonstrated that as muscular endurance and strength increased, performance speed on the tasks improved. Finally, the research of Sothmann et al. (2001) utilised a test battery of field measures such as hose drag, pack carry, arm lift and arm endurance exercises and found that the combined scores could significantly predict performance time in fire-suppression exercises (82% and 72% of successful and unsuccessful performers).

However, it is important to note that fitness level should not be considered a sole determinant of whether an individual is an effective firefighter or not. Previous researchers have noted that experienced firefighters tend to be able to compensate for any apparent weakness in their performance by adopting more efficient working procedures that often mask shortfalls in their physical capability (Nevola, 2003). When working in teams it is even more difficult to detect the shortcomings in the individual employee's physical abilities, despite placing an often greater and unfair burden on the rest of the team mates.

2.5 Psychological responses to self-contained breathing apparatus tasks

Despite its relatively small size, the brain is responsible for the maintenance and regulation of all functions whenever we simply perceive, think, or move. As a result, there needs to be a consistent delivery of oxygen to enable these tasks, with any interruption in supply capable of leading to unconsciousness within seconds, and irreversible changes resulting in cell death within minutes (Parrot et al., 2004). The researchers state how although glycogen levels stored in the brain are capable of sustaining function for up to 10 minutes there is no storage capacity for oxygen, which has important implications for firefighters who often operate within oxygen deficient atmospheres with SCBA.

In addition to the physical aspects, firefighting tasks have a number of psychologically-based demands, and firefighters must be able to manage and deal with each of these before, during, and after an incident to negate any impact stressors may have upon performance. Despite the potential impact of psychological stressors upon performance, the effects during SCBA tasks are yet to be fully explored. For example, when highly trained elite soldiers undertaking five-day field exercises have been exposed to a multi-stressor environment, severe decrements in mood and cognitive performance are found, including impairment in both simple (i.e. reaction time and vigilance) and higher (learning, memory and reasoning) cognitive functions. The 20% decline in reaction time performance during the field tasks were found to be greater than the impairment of being both hypoglycaemic and being legally drunk, leading to an increased likelihood of injury or death during combat operations (Lieberman et al., 2005).

A review of research into the factors influencing psychological function associated with firefighters' performance can be categorised into three areas, and is displayed in figure 2.3. Each of the specific areas will then be subsequently explained in greater detail.

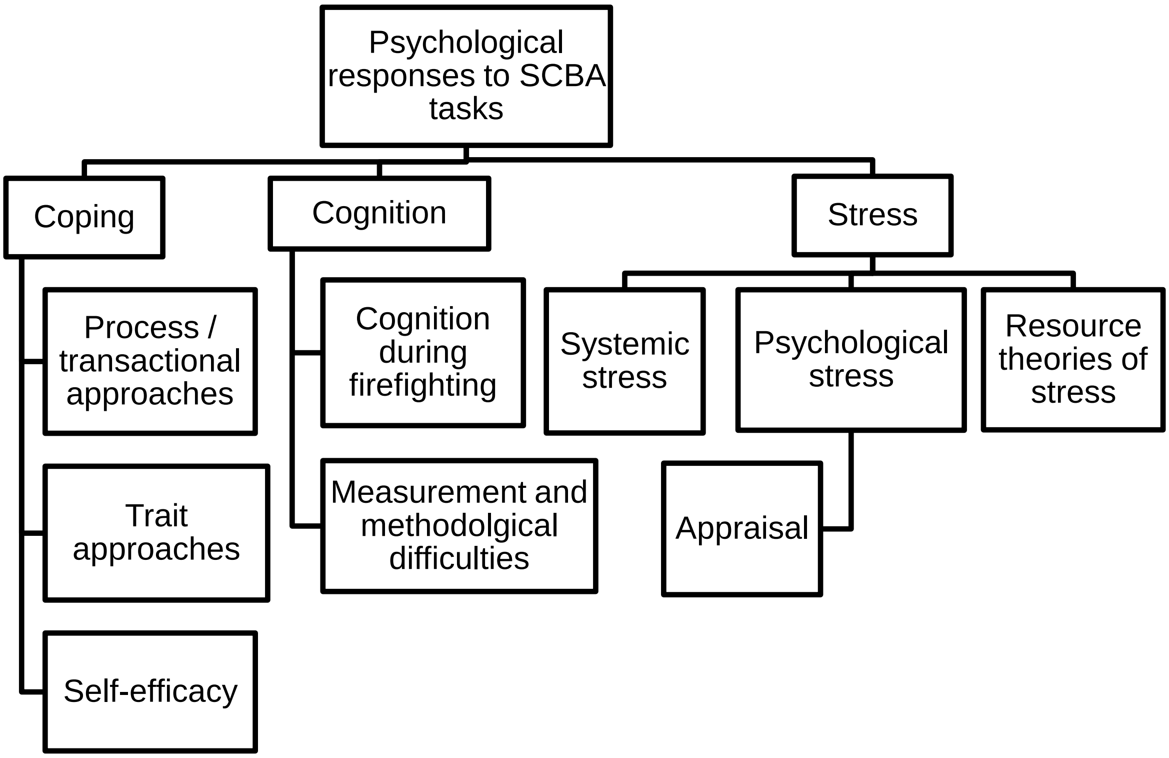

Figure 2.3. Factors influencing psychological function associated with firefighters' performance when wearing SCBA

2.5.1 Cognition in extreme environments

Paulus et al. (2009), when describing the impact of extreme environments on cognitive performance, state that there is still currently insufficient research to suggest that the uniform deterioration of cognitive performance in extreme environments occurs, and suggest that it is the unique and specific characteristics of the environment encountered that will inform the relationship between physical exhaustion and cognitive performance. Although the review of psychological task performance by Ramsey (1995) suggests that firefighters working under hot conditions above 30^{o} C may be affected by the heat when performing more complex tasks (such as tracking and vigilance), research exploring the effects of operating in conditions over 150^{o} C (the temperatures likely to be present during firefighting activities) (Love et al., 1996) is required before more definitive effects can be attributed to this population.

Further research by Lieberman et al. (2006) in laboratory environments suggests that a range of cognitive measures performed by military personnel can lead to decrements in cognitive performance and mood. In particular, simple tests of cognitive performance are shown to be more sensitive to the effects of multi-stressor environments than complex tasks, with examples also being found to exist following exposure to sleep loss. Impaired mood, including increased fatigue, feelings of depression, confusion, and increased anxiety were found to be reliable predictors of degraded cognitive status, with impaired mood also being associated with impaired cognitive performance (Lieberman et al., 2006). Whilst the effects of cognition have yet to be fully investigated in firefighters, anecdotal evidence by Levenson and Acosta (2001) suggests that degradation of cognition is likely to occur amongst emergency personnel and disaster victims.

2.5.1.1 Cognition during firefighting scenarios

There are a number of practical benefits to an increased understanding of the potential changes in the cognitive abilities of a firefighter during incidents. During SCBA tasks, it has been argued that because of the importance of consistent mental acuity, firefighters should be withdrawn from a risk area as soon as any impairment of cognitive performance is suspected, even if this results in lower exposure limits than those based upon the physiological risk (Hancock & Vasmatzidis, 1998). Although this may be considered an appropriate recommendation, its application to SCBA scenarios is difficult due to the limited knowledge of what constitutes impaired cognitive performance, or even if this exists during SCBA tasks, and at present there is no protocol or procedure for the identification of impaired mental performance during SCBA tasks.

A number of studies have utilised a range of environments to try to determine the cognitive performance of firefighters, with differing results and facets of cognition being assessed. Beauchamp (2010) investigated cognitive function and recovery of firefighters following a treadmill task conducted in a heated room wearing personal protective equipment. Despite the 50 minute task inducing significant physiological strain, cognitive performance (as measured by serial addition) was neither enhanced nor impaired following exercise, although decreased attention was noted two hours following exercise once core body temperature had returned to baseline levels, suggesting possible delayed impairment of cognitive function. These findings are consistent with earlier research by Rayson et al. (2005) in the UK who found minimal increases in rapid visual information processing (RVIP) time, but no changes in spatial memory span (SMS) or reaction time (RTI) 30 minutes after completing a SCBA live fire task, although the researchers acknowledge that any effect could have been lost during the transition period from the activity to undertaking the cognitive task.

Alternatively, in a study of cognition following repeated strenuous live fire drills in male recruit firefighters (Smith et al., 2001), participants were required to complete three consecutive trials of firefighter drills with each trial consisting of the same four tasks. Although increases of around 25% were found in state anxiety following the trial, no changes were found in reaction time and there was a tendency for errors to increase, with participants' incorrect responses to cognitive tasks increasing 4.2% following the first trial before making 4.6% and 12% more incorrect responses after the second and third trials. Whilst the researchers identify a number of methodological shortcomings with the research and state that not too much should be made of the data given the small (seven participants) sample size, they also state that there is some indication of impairments in cognitive function due to the increase in percentage of incorrect responses to a relatively simple cognitive task.

2.5.1.2 Measurement and methodological difficulties

One of the difficulties associated with the measurement of cognitive performance in firefighters is the lack of a specific measurement tool for assessment purposes within this occupation, or the establishment of the exact cognitive skills most pertinent to firefighting. Such issues have led Barr et al. (2010) to suggest that the few studies that have attempted to measure changes in cognitive performance of firefighters following simulated firefighting activities have done so using mental performance tests such as simple reaction time, which are not of primary performance during firefighting. As a result, it is unlikely that a difference of a few milliseconds to complete the tests is likely to have any detrimental effect on the overall performance of a firefighter at an incident.

Attempts to introduce measures of cognitive predictors of performance at the firefighter recruitment stage has also lead to a number of problems, including the reluctance of developers to share technical reports, predictor range restriction, unreliable criterion variables, and un-cooperative cohorts (Henderson, 2010). Because cognitive measures are often assessed during training environments by researchers, difficulties have been identified when applying changes in cognitive performance to real-life situations due to inconsistencies in the validity of simulated tasks, as well as safety and training limitations in making the cognitive tasks fully immersive without interfering with the firefighting tasks being undertaken. Whilst general cognitive tests can be applied into research methodologies, the variance of firefighting taks means that different activities require different abilities at different times and for different reasons (Henderson, 2010). Often it is the unknown stimuli of the environment that dictate the specific cognitive ability to be utilised. For example a house fire may require the SCBA wearer to utilise spatial awareness skills to locate a casualty in a room, whilst another SCBA incident may primarily require short term memory retrieval to memorise the route they have taken into the building. Just as there can be an unlimited type of operational incident, it could be argued that there are also an unlimited number of cognitive ability ‘combinations’ and weighting utilised at these incidents. As a result, the establishment of the ways to measure the impact or importance of individual facets of cognition is recommended to further understand the influence of cognition upon firefighting performance.

2.5.2 Stress

Firefighting can be considered a stressful occupation. According to the Cooper Occupational Stress ratings (Cooper et al., 1988) - a 10 point scale from 1 (‘least stressful’) to 10 (‘most stressful’) taking into account health findings - firefighting can be considered to score 6.3 (‘very stressful’). This scored higher than professions including the armed forces (4.7), professional sport (5.8), and ambulance service (6.3), although less than mining (8.3) or civil aviation (7.5). Despite this, the impact of stress upon firefighter performance and well-being is yet to be fully investigated, with researchers such as Gohm et al. (2001) stating that there is a tendency of research to consider the psychological processes of individuals in response to ‘mild’ situations involving time pressures, noise, task load, or threat, despite firefighters regularly being exposed to more ‘acute’ stress situations.

2.5.2.1 Defining stress and stressors

Hans Selye originally conceptualised what is now considered ‘stress’ by describing a consistent pattern of mind-body reactions and ‘wear and tear’ on the body in response to a demand placed upon it (Selye, 1956). The demand Selye referred to was known as the ‘stressor’, which then lead to a ‘stress response’. In brief, stressors can be considered as the disrupting conditions that create the need for the readjustment that can potentially cause stress (Selye, 1956), whereby different environments and different stimuli will be seen as more demanding to different individuals, and as an example firefighters will react differently when these arise. More recent definitions by Aldwin (2007) describe how the quality of experience, produced through an interaction between the person and their environment transaction leads to either over-arousal or under-arousal resulting in psychological or physiological distress to the individual.

However, there are difficulties in defining exactly what stress is, and at present there is no uniform agreement as to how to define the concept. Stinchcomb (2004) describes how to some people, stress is a stimulus in the environment that creates tension, threat, and anxiety, and a need to re-adjust as a result. Put simply, stress is simply the manner in which the body responds physiologically and psychologically when trying to adjust to stressful stimuli. Often this can lead to symptoms ranging from physiologically based ailments such as headache, stomach ulcer, and heart attacks, to psychological symptoms including irritability, anxiety, depression and panic attacks. However, these symptoms can be considered more a response to stress or symptoms of exposure to stress, and not specifically stress itself (Stinchcomb, 2004).

Stress may be further categorised as either ‘cumulative’ stress with ‘eroding’ properties (such as the daily hassles of life) or ‘traumatic stress’ that is characterised by sudden, intense items or situations. Exposure to stressors may be brief with clear start and finishing points (acute stressors), or may exist for an extended period without a clear end (chronic stressors), and can be induced by anticipation of a stressor, an on-going stressor, or exposure to a previous stressor. Crocker et al. (2010) suggest that stressors can be organised at a ‘macro’ level and include social, interpersonal, emotional, physical, psychological, and organizational levels, or they can be a ‘micro’ levels such as performance goals, technical demands, mistakes, or emotional states related to the individual.

Whilst most people try to avoid stress in everyday life, it is important to note that not all stress is bad stress, and in some cases stress can even improve or lead to superior individual performance. In evolutionary terms, stress signals danger and protects us, motivates us to achieve, and leads to the development of courage. In the longer term, successful experiences in dealing with stress can build important coping and problem solving skills that are then used to manage future stressful events and enhance persistence under such conditions. In the immediate short term, elementary work by Yerkes and Dodson (1908) has demonstrated that an ‘inverted-u’ relationship exists whereby performance on a task improves as the stressor stimulus reaches a moderate level before decreasing as stimulus strength increases beyond this point.

Although a number of the physiological responses to a stressor are seen as adaptive, a stress response can also create negative effects in a number of psychological areas, such as in individual and group performance, decision making, and perception (Mandler, 1993). In terms of the time taken to complete a task, stress has been reported to slow cognition and individual information processing, resulting in the time taken to complete a given task almost doubling with the introduction of an external stressor (Idzikowski & Baddeley, 1983). When multiple tasks are required to be completed, this is thought to lead to stress in the form of task overload, leading to a reduction in the quality of individual performances and an increase in the magnitude of the performance compared to a single task performed by the individual. Avoiding stressors is not recommended, and prolonged avoidance of stressors has been linked to problems within working memory affecting the brain, heart, and other muscles (Tsigos & Chrousos, 2002).

Stress leads to activation of the sympathetic nervous system (SNS) and hypothalamic-pituitary-adrenal (HPA) axis. Mediated by the catecholamines adrenaline and noradrenaline, this rapid response by the SNS is then followed by a comparatively slower response of the HPA axis resulting in the release of glucocorticoids (GC) from the adrenal cortex (Shoofs et al., 2008). Although less extensively studied that declarative memory, the impact of SNS and GC concentrations upon working memory is considered to exist in acute stress. Described as the structures used for temporarily updating, maintaining and updating information (Baddeley, 2003), working memory can be significantly impaired following exposure to an acute laboratory stress task; however, these impairments are reduced with prolonged exposure to the task (Shoofs et al., 2008). Furthermore, in extreme cases exposure to stress associated with psychological trauma may even mimic mild traumatic brain injury (Tanielian, 2008) leading to detrimental effects upon memory, mental function, verbal acuity, and receptive language.

Previous research of organisational stressors in the Police force has identified that stressors have the potential to drain energy and enthusiasm, leading to a wearing down process that may lead to burnout and taking a toll on physical, emotional and mental health (Stinchcomb, 2004). On the emergency scene, stress symptoms of US emergency service personnel have been found to range from depression and impaired cognitive functioning to second guessing judgment (Regehr, Hill & Clancy, 2000).

2.5.2.2 Fire service stressors

In response to the potential occupational consequences of stress, the United States Fire Administration (USFA) created a Stress Management Model Programme for maintaining firefighter well-being in 1991. Since firefighting typically involves acute stressors within work based situations the USFA programme describes how stress is one of the most serious occupational hazards facing the modern fire service and that it is important to recognise exactly how stress can adversely affect firefighter health, job performance, career decision making, morale, and family life (Green, 1991). Petrie and Rotherham (1982) found that in a sample of US firefighters, daily stress in the fire and rescue service occurs irrespective of length of time in the job, age, rank, or factors in the personal lives of subjects such as marital status, marital satisfaction, income, or number of children. In essence stress is something that firefighters at all stages of their career will encounter on a daily basis.

Common examples of stressors in the fire and rescue service may include exposure to extreme heat, lack of sleep, risk of injury or time pressures. Once an individual has been exposed to this stressor, a psychological stress response will occur including elevated heart rate, dilated pupils, increased blood pressure, or an increase in the electrical conductivity of the skin (galvanic skin response). An example of this latter measurement was undertaken by Del Sal et al. (2009) using Italian military firefighters who found that during simulated fire conditions galvanic skin response levels were found to be elevated during the work phase and did not return to normal values until 12 hours following the activity, suggesting high levels of psychological stress remain in firefighters even after physical recovery.

Many firefighters are exposed to scenes that have gruesome sights, sounds, smells, taste, and / or touch, that may result in flashbacks of the scene (Regehr & Bober, 2005), and following exposure to stressors at that incident may then be immediately called from one horrific scene to another. Other researchers, such as Beaton et al. (1998) have categorised five components of on duty firefighter stressors as being:

- catastrophic injury to self or co-worker
- gruesome victim incidents

- rendering aid to seriously injured
- vulnerable victims
- minor injury to self
- exposure to death and dying

Similar incident-based stressors have also been reported by Baker and Williams (2001) and include firefighters' concerns about 'safety of oneself and colleagues'; 'handling dead bodies'; and 'attending a chemical incident'.

Whilst few firefighters are immune to stress during an incident, there are a number of intervening variables or moderators such as training and personality that can reduce the performance decrement that is caused by stress. Figure 2.4 demonstrates a flow chart by Kavanagh (2005) of the moderators that may affect the relationship between stress and performance, although it is important to note that some moderators may function as both type one and type two moderator, depending on the context.

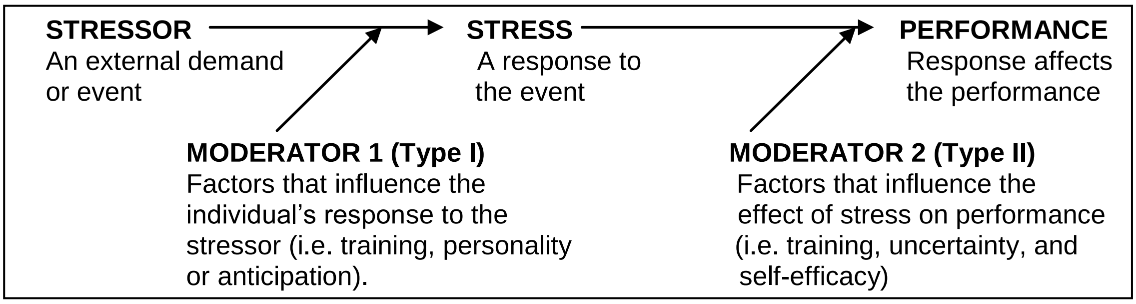

Figure 2.4 Moderators in stressor-stress-performance relationship (adapted from Kavanagh, 2005)

Thus, there are a number of moderators in both the stress and performance of firefighters and therefore all personnel called upon to attend an incident must find an effective means of managing the stressors present during the event. This will also include the utilisation of skills that have been acquired through training and personality, as well as both the influence and impact of stress.

2.5.3 Relationships between stress and stressors

Khrone (2002) states that the theories that focus on the specific relationship between stressors and stress can be grouped into two distinctive categories, the first being approaches to systemic stress based in physiology and psychobiology, and approaches to psychological stress developed in the field of cognitive psychology. In addition there are the resource theories of stress that can be considered to sit between the systemic and psychological viewpoints (Khrone, 2002), that consider the resources that preserve well-being in the face of stressful encounters and not specifically the factors that create stress.

2.5.3.1 Approaches to systemic Stress

Hans Selye is credited with the postulation of the general adaptation syndrome (GAS) (Selye, 1936), a framework that represents the 3-stage stereotyped physiologic response to a stressor, and is demonstrated in figure 2.5. This theory encompasses the emergency reaction of the sympathetic nervous system and adrenocortical system to stress.

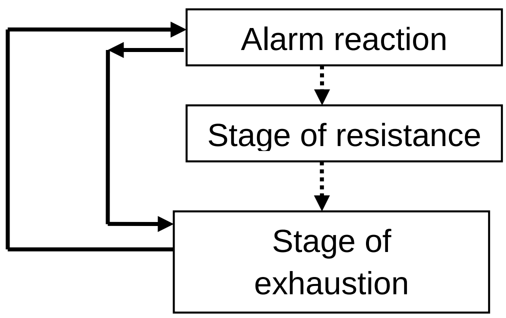

Figure 2.5. Schematic Representation of the General Adaptation Syndrome (GAS) (adapted from Selye, 1936).

The first stage, the alarm reaction, encompasses the release of adrenalin and from the adrenal medulla and glucocortoids from the adrenal cortex to help to restore homeostasis. Restoration of homeostasis then leads to the second stage, a 'stage of resistance', whereby the symptoms of the alarm reaction disappear due to the defence and adaptation to the stressor over time, although whilst resistance to the noxious stimuli increases, resistance to other kinds of stressors may decrease. If the stressor persists, the stage of exhaustion is reached and the capability of adapting to the stressor is exhausted. The stages of alarm reaction reappear but resistance is no longer possible, leading to irreversible tissue damage and death if the stressor persists.

Despite the influence of GAS on a new generation of stress researchers, Krohne (2002) has suggested the potential weaknesses of this approach. This includes the concern that by conceptualising stress as a reaction to a multitude of different events, the stress concept became a 'melting pot' for diverse terms such as anxiety, threat, and arousal, amongst others, thus losing its scientific value. Furthermore, unlike the physiological stress investigated by Selye, stress experienced by humans is almost always the result of cognitive mediation, and in his theory he fails to specify the mechanisms that may explain the transformation from objective noxious events to the subjective experience of being distressed. Furthermore, the GAS is no longer interpreted to mean that all types of stress invoke the same stereotypical response, with the hypothalamic-pituitary-adrenal axis and noradrenergic nerves having different patterns of response to the different type of stressor (McEwan, 2005). The stage of exhaustion is also limited due to increased understanding of the knowledge that stress mediators can be both protective or damaging depending upon the time course of their enaction with the exhaustion of 'stress mediators' and not 'defence mechanisms' causing problems (McEwan, 2005). Finally, and of most relevance to this thesis, is the failure to take into account coping mechanisms a mediator of the stress-outcome relationship.

2.5.3.2 Approaches to psychological stress

From its first presentation in 1966, the stress theories of Richard Lazarus have had a number of revisions, and can be regarded as a psychosocial and relational concept. Within this model, stress is viewed as a relationship between the individual and their environment, as opposed to a specific pattern of physiological, behavioural, or subjective reactions to a specific kind or external stimulation (such as with the GAS model). Two concepts are central to this stress theory: 'appraisal' of the situation and evaluation of its impact upon the well-being of the individual; and 'coping' where the individual manages specific demands of the stressor. Coping within this model will be discussed later in this chapter alongside alternative models within psychology.

Appraisal

One of the key aspects of Lazarus and Folkman's (1984) theory is the notion of the person-environment transaction, and the idea of 'appraisal'. This is based upon the idea that emotional processes (including stress) are dependent upon the actual expectancies that persons have regarding the significance and outcome of a specific encounter. Appraisal also helps to explain why individual differences exist in the quality, intensity and duration of elicited emotion experienced in environments that are environmentally and objectively identical for a group of individuals. Stress responses are considered to only occur when a person's appraisal / evaluation of the environment is deemed to have a significant effect upon their well-being and that exceeds their current coping resources.

In the fire service, research into the catastrophic appraisals of trainee firefighters by Bryant and Guthrie (2005) suggest that an individual's appraisal of a traumatic event and capacity to respond to the experience plays a crucial role in how they adapt to the experience. They found maladaptive appraisals to cause more stress-related symptoms in new firefighter recruits (Bryant & Guthrie, 2005), thereby making it essential for firefighters to learn about adaptive appraisals and effective coping. Similar to this, Beaton et al. (1998) demonstrated differences in appraisal and stress using 173 US urban firefighter / paramedics who considered the perceived stressfulness and frequency of 33 actual or potential duty related stressors across a six-month period, including incidents considered rare and catastrophic, and those experienced on a frequent basis. There were found to be differences in participants' appraisals of the intensity of the stressor, whilst their perceptions of the stressfulness of the incident was the same whether or not they had experienced it in the last six months, and was also independent of the frequency they had reportedly experienced another particular incident stressor in the same timescale. This suggests that even when a group experiences a similar incident there are likely to be a wide range of appraisals between individuals.

Lazarus and Folkman (1984) have distinguished between the specific elements of appraisal. 'Primary appraisal' and its components describe the initial assessment of an event and its impact on our well-being, as well as relevance to goal commitments, values, beliefs about self, and situational intentions. 'Secondary appraisal' relates to the evaluation of resources at an individual's disposal and coping options available that can be used to minimise the stress in the situation such as identifying emergency exits during an appraisal of harm or threat. The individual will evaluate various coping options to prevent harm and also increasing the options for benefit. Whilst not actual coping, secondary appraisal is the instance where the individual decides what they are going to do to cope (Lazarus, 1999).

Khrone (2002) describes how three specific secondary appraisal components can be distinguished: 'blame or credit' results from an individual's appraisal of who was responsible for a certain event; 'coping potential' refers to a person’s evaluation of the prospects for generating certain behavioural or cognitive functions that will positively impact upon the encounter; and finally ‘future expectations’ consider the appraisal of a further course of an encounter with respect to goal congruence or incongruence. Specific patterns of primary and secondary appraisal will then lead to three different kinds of stress that can be identified in research by Lazarus and Folkman (1984). ‘Harm / loss’ consists of the psychological damage that has already happened, whilst different individuals in the same situation may feel joyous about the coming event and feel confident about mastering (‘challenge’) it or concerned about the potential damage due to the anticipation of harm that may be imminent (‘threat’). Finally, ‘benefit’ relates to the individual feeling positively toned emotions immediately following the event as well as experiencing long term positive emotions. It is suggested by changing a threat appraisal to a challenge that this reappraisal may lead to adaptive behaviours through effective coping (Lazarus, 1999).

At present, one of the difficulties in stress research is identifying exactly what it is that makes something psychologically threatening (Lazarus, 1999). It is not the particular situation that mediates a stress appraisal, although certain underlying properties exist which underpin all situations perceived as stressful. As a result, rather than focusing upon the precise situations that lead to stress the individual should focus upon the underlying properties of situations that lead to stress appraisals. In line with this Lazarus and Folkman (1984) have identified the eight underlying properties of stress. These include:

- Novelty – where the situation has not previously been experienced
- Predictability – where established expectancies are no longer met
- Event uncertainty – the likelihood of an event’s occurrence
- Imminence – the period of anticipation before an event occurs
- Duration – whereby the length of an event and in particular typically longer durations, are considered more stressful
- Temporal uncertainty – where the event is sure to happen but the individual is uncertain exactly when
- Ambiguity – the lack of situational clarity that then leads to unclear or insufficient information for appraisal
- Timing of events in relation to the life cycle – When events occur at the same time as other stressful events in the individual’s life.

In addition, Thatcher and Day (2008) have also identified a further two underlying properties that may be present in sports environments. ‘Self and other comparison’ relate to the ability of an opponent to perform well, whilst ‘inadequate preparation’ describes being physically unprepared for competition, as well as factors such as lack of sleep or lack of food. In particular the latter property would be applicable to firefighting scenarios and may warrant further validation within these environments.

Therefore, for a situation with personal meaning to be appraised by the individual as stressful, at least one of the properties stated above must be present. Conversely, if none of the factors are present, or if one or more properties are present but no personal significance is attached then it will not be appraised as stressful. Firefighting in SCBA can realistically be expected to have a high likelihood of producing each of these factors in the individual.

2.5.3.3 Resource theories of stress

Considered as a bridge between systemic and psychological viewpoints, resource theories of stress consider the resources that preserve individual well-being in the face of stressful encounters rather than the factors that create stress. This includes resources identified by Khrone (2002) such as social support (including instrumental, informational, appraisal, and emotional types), sense of coherence, hardiness (including internal control, commitment, and sense of challenge), optimism, and self-efficacy. The conservation of resources theory of stress (Hobfoll, 1989), assumes that stress occurs in any of three contexts:

i- When people experience loss of resources
ii- When resources are threatened
iii- When people invest their resources without subsequent gain.

Four categories of resources are also proposed, consisting of ‘object’ resources (i.e. physical objects such as home, clothing or access to transport), ‘condition’ resources (i.e. employment or personal relationships), ‘personal’ resources (such as skills or self-efficacy), and ‘energy’ resources (means that facilitate attainment of other resources, such as money or knowledge).

Hobfoll et al. (1996) offer a number of principles derived from the basic assumption of the conservation of resources theory. There is the idea that loss of resources is the primary source of stress; the notion that resources act to preserve and protect other resources (i.e. self-esteem); and the idea that following stressful circumstances, individuals have an increasingly depleted pool of resources available with which to combat further stress, which then impairs individuals' capability to cope with further stress. This latter principle provides insight into the interplay of resources and outcomes and how they change over time as stressors unfold, demonstrating the importance of investigating both the effect of resources on outcome and of outcomes on resources.

2.5.4 Coping

There is currently limited empirical research into the coping strategies of firefighters, despite the development of an abundance of definitions, styles and components in general psychology research. Within coping research, there are two dominant perspectives: the 'trait' approach described by Carver, Scheier and Weintraub (1989), and the 'process' (or transactional) oriented approaches attributed to Lazarus and Folkman (1984). One of the key differences between the trait and process-orientated approaches is the significance given to the psychological and environmental contexts in which the coping takes place. Coping associated with a trait orientated approach assumes that coping is primarily a property of the person, and variations in the stressful situation are of relatively less importance. Process-orientated approaches, however, see the context as a critical factor as coping is assessed as a response to the psychological and environmental demands of specific stressful encounters.

In order to cope, it is necessary for the individual to initiate 'coping strategies'. These are considered to be the different strategies and tactics incorporated to deal with stressful situations, with the aim of leading to a perceived effective coping outcome from the individual in being able to deal with the demands identified. Neither the coping strategy employed, nor coping effectiveness, is yet to be fully explored in firefighters, and to date there is no clear consensus regarding which coping strategies are the most effective for problem solving, preventing future difficulties and managing psychological distress. Of the limited studies that have considered the impact of stressors and coping strategies in firefighters, the emphasis has typically been upon single large disasters such as the Oklahoma City Bombing (North et al., 2002), indices of post-traumatic stress disorder (Mitani et al., 2006), or results of chronic behaviours attributed to exposure to stressors such as alcohol consumption (Murphy et al., 1999). Studies of stressors have predominantly focused upon US-based firefighters (such as

Beaton et al., 1998), and given the cultural differences that may exist due to potential differences in job role, a clear approach applicable to UK firefighters is required.

2.5.4.1 Process / transactional approaches to coping

The process approach incorporates interactions between a person's internal (i.e. beliefs about self, goals, and values) and external (i.e. situational) environments (Lazarus, 1999). Coping within this model is closely related to the concept of 'cognitive appraisal' discussed earlier, forming the second part of the theory of person-environment transaction approach to stress developed by Lazarus and Folkman (1984). The process is presented diagrammatically within figure 2.6. Within this approach, coping is also described as an on-going process that includes all consciously and deliberately executed attempts by the individual to manage appraisal demands that exceed their resources (Folkman et al., 1986; Lazarus, 1999). Responses used to manage appraisal demands will include the utilisation of cognitive, affective and behavioural efforts to manage threatening events (Lazarus & Folkman, 1984). The actual coping process will then be initiated in response to the individual's appraisal that goals considered important to themselves have been harmed, lost, or threatened (Folkman & Moskowitz, 2004).

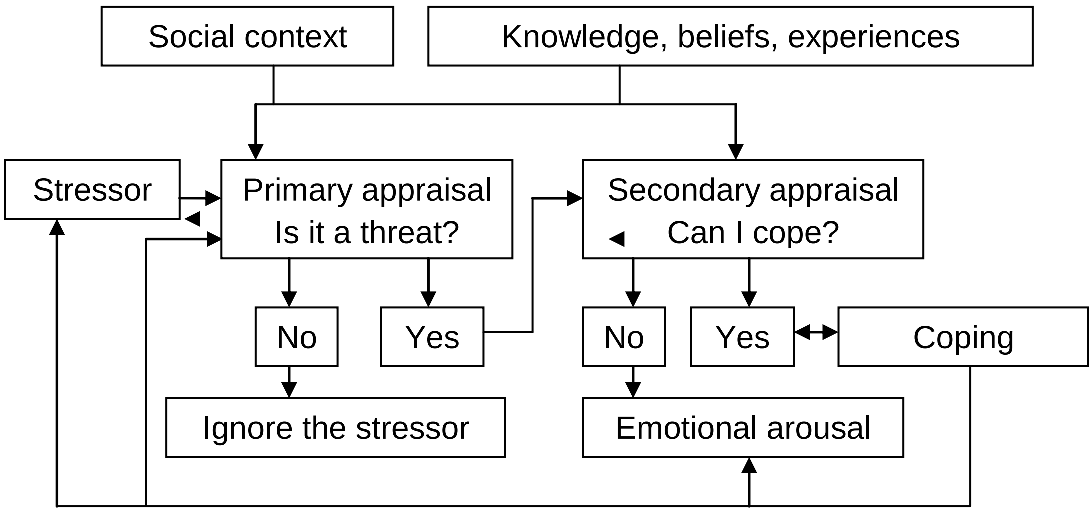

Figure 2.6. The stress and coping model proposed by Lazarus and Folkman (1984).

Coping is thus considered to be 'process-oriented', meaning that it focuses upon what the person actually thinks and does in a specific stressful encounter and how these thoughts and actions change as the encounter unfolds, and change over time in response to objective demands and subjective appraisals undertaken by the individual (Stone et al., 1991). Coping is also considered to be ‘contextual’, and has the potential to be influenced by the individual’s appraisal of the demands of the situation and their individual resources available. Finally, in this model no assumptions are made about what is good or bad coping; the individual simply attempts to manage the demands of the situation whether or not these efforts are successful. This theory is in contrast with the trait approach, in that it looks at what the person usually does, emphasising stability as opposed to change that occurs during the process or context.

Process-oriented coping techniques have been sub-categorised by Lazarus and Folkman (1984) as being either problem focused or emotion focused. In a problem focused approach, attempts are made by the individual to modify, or minimise the stressors or situation. Using the Ways of Coping (WOC) Checklist (Folkman & Lazarus, 1985), problem focused techniques can be further categorised as confrontive coping (aggressive, sometimes risky attempts to change the situation) and planful problem-solving (using an analytic approach to change the stress inducing situation).

Emotions focused approaches meanwhile, are considered useful as a short-term strategy and utilise mechanisms such as positive reappraisal, acceptance, and denial to moderate the negative emotions being experienced and minimise stress reactions without addressing its cause. The WOC categorises this area as the individual utilising methods such as ‘distancing’ (detachment from the stressor), ‘self-control’ (efforts to control feelings and actions), ‘accepting responsibility’ (trying to put things right), ‘escape-avoidance’ (wishful thinking or engaging in other duties), and ‘positive reappraisal’ (focusing on personal growth including focusing on religion). According to Auerback and Gramling (1998) most people will engage in some emotion-focused coping under high-level stress in order to suppress high anxiety and allow us to evaluate situational demands, plan and perform effectively. A study by Strenz and Auerbach (1988) involving the 4 day mock abduction of pilots and flight attendants by terrorists found those who used emotional focused strategies such as deep breathing, or imagining they were elsewhere had the lowest stress levels during the acute stressor of captivity.

Finally, the notion of seeking emotional support can be considered both problem and emotion focused, as attempts may be made to find information from others about the stressor (problem focused) and seek emotional support from others (emotional focused) (Thoits, 1986). It has been found that the perception of availability of interpersonal resources (such as social support) rather than the actual amount of support that is available is closely related to how people deal with stressors (Sarason et al., 1990) in this facet.

Endler and Parker (1990) have also suggested an alternative to the original categories proposed by Lazarus and Folkman (1984), with the introduction of an 'avoidance' facet, with initial research suggesting that firefighters use avoidance coping by keeping their feelings to themselves and by deliberately avoiding telling others how bad things really are (Dowdall-Thomae, 2009). Skinner et al. (2003) recommend that the methods of problem focused, emotion focused, and emotional support coping methods should no longer be used but instead replaced with 13 groups (or 'families') of coping identified by confirmatory analysis of 400 identified ways of coping (Thatcher, Jones & Lavalee, 2012).

The notion of an immediate outcome of coping in a stressful situation can be applied to firefighting scenarios, with the overall judgment of whether the situation or stressor was successfully resolved based upon an individual's values and goals, as well as their expectations concerning various aspects of the encounter if the Lazarus and Folkman (1984) framework is applied. For example, there may not have been a resolution of the stressor but the individual may evaluate the outcome favourably if they considered that the demands of the stressor were managed as well as could be expected with the resources available. Alternatively, the situation may have been resolved successfully but the individual may still see the outcome as unsatisfactory if the solution was inconsistent with other values and goals, as well as with what they thought they could achieve therefore creating additional conflict in the individual's social context. In a fire situation this is a key consideration, due to the fact that multiple factors are outside of the control of the individual and may well contribute significantly to the final outcome of the incident. An example of this could be a house fire with persons trapped. The role of the individual may be to search and locate casualties within the property (and thus deal with the situation specific stressors involved in this environment); however the casualty within the property may already be deceased. If the model above is utilised the individual may have coped successfully with all stressful demands but still be unhappy with the outcome. Alternatively, another firefighter at the same incident may have utilised a coping strategy at the same incident that did not deal with the situation specific stressor but still managed to rescue a casualty and resolve the incident successfully. As a result, the perceived outcome of an incident where coping strategies have been utilised remains an area for further fire and rescue research.

2.5.4.2 Trait approaches to coping

An alternative approach to coping is considered to be the more stable strategies within a trait approach. Within trait approaches to coping, it is suggested that people do not approach each situation with new strategies but instead rely upon a preferred set of coping strategies that remain relatively fixed across time and circumstances (Carver, Scheier & Weintraub, 1989). Stone et al. (1991), state how early approaches to psychological coping generally conceptualised a stable and enduring trait, measured through interviews and personality tests created in the tradition of trait assessment, with the individual simply indicating the presence or absence of that trait in a series of items.

Unlike in process oriented coping approaches, Carver, Scheier and Weintraub (1989) consider the distinction of problem or emotion focused coping strategies to be too basic, and that treating these two strategies as mutually exclusive has led to an oversimplification of the way coping operates (Skinner et al., 2003). For example, some emotion focused responses may involve denial, whilst others involve positive reinterpretation of events, and others involve seeking out social support. The researchers argue that these responses are very different from each other and may have very different implications for a person's success in coping. Problem focused approaches meanwhile, are described as potentially offering several distinct activities such as planning, taking direct action, seeking assistance, and waiting before taking action; yet it is suggested that these should be studied separately and therefore measured separately. As a result, this approach includes the application of 13 conceptually distinct scales measured through the COPE inventory, which is considered to have excellent psychometric properties (Stone et al., 1991).

2.5.4.3 Self-efficacy

Self-efficacy is a belief in one's competence to tackle situations, and influences how people think, feel, motivate themselves and act (Bandura, 1997). Sources of self-efficacy include previous performance accomplishments, vicarious experience, verbal persuasion and level and quality of physiological states. Self-efficacy may influence coping as it represents a personal resource which if high can lead people to choose to perform more challenging tasks, invest more effort, recover more quickly from setbacks and remain committed to their goal (Schwarzer et al, 2005).

In relation to fire fighting Prati et al (2010) found that self-efficacy may ‘buffer’ the impact of perceived stressful encounters on quality of life. Similarly, Regehr et al (2000) noted that self-efficacy was associated with lower levels of traumatic stress and depression in fire fighters.

Based on Bandura’s theory and previous research it would be logical to assume that more experienced fire fighters would have higher levels of self-efficacy than new recruits. However, Regehr et al (2003) found the opposite to be true, with experienced firefighters showing lower levels of self-efficacy. Potential explanations offered for this finding included limited opportunities for development in conjunction with increasing levels of responsibility.

It is clear that the relationship between self-efficacy and coping in firefighting is complex and further study is required. Given the multidisciplinary nature of the thesis and the variety of psychological variables that could influence coping, further investigation into the specific role of self-efficacy was not possible. Therefore whilst self-efficacy was acknowledged as a related construct, it was not directly assessed. That said, the incorporation of qualitative interviews into the thesis did afford the opportunity for self-efficacy related issues to emerge in the discussion if participants felt them to be relevant.

2.6 Firefighter deaths and injuries on duty

The review of the literature has identified that firefighting is an extremely stressful occupation, with a number of tasks imposing a high level of strain upon the firefighter whilst performing in an environment with the potential for serious injury or death. Exploration of the current rates of on-duty injuries and deaths at operational incidents indicate an increase in the number of psychological and physical injuries to firefighters despite the advances in technology, personal protective equipment, engineering controls, environmental management, medical care, and safety legislation (Kunadharaju et al., 2011). As a result, research is recommended that has the potential to increase knowledge regarding the occupational demands and formulate methods of reducing the impact upon performance or wellbeing of firefighters.

2.6.1 Psychological injury

Being present at a fire scene and being exposed to extreme stressors may be hazardous to the psychological well-being of firefighters, and carries a potential risk of the individual developing post-traumatic stress disorder (PTSD), a syndrome characterised by flashbacks, nightmares, intrusive memories, avoidance of things that are reminder of the event, sleep problems and hypervigilance. Research by O'Donnell (2003) found that almost 1 in 5 firefighters are affected by PTSD symptoms, with twenty four percent of UK firefighters studied demonstrating PTSD scores considered to be at a 'significant' level, and 7% of their sample displaying 'severe' symptoms. When the researchers included the scores of those who displayed 'mild' symptoms, the percentage rose to 69.6% of the sample affected. Despite 94% of UK senior fire officers having stated that they considered PTSD to be a problem for fire brigades (O'Donnell, 2003), there remains limited research that has addressed the solutions available for PTSD management in fire service personnel.

However, whilst PTSD may impact significantly upon quality of life, and present a risk within the emergency services, there is also an alternative view that whilst negative aspects to traumatic events are understandable, positive effects can occur through post traumatic growth (PTG) (Linley, Joseph & Loumidis, 2005) resulting in positive life changes and personal growth by the individual. However, the issue of PTSD within the fire and rescue service represents a potential and likely risk to the psychological health of serving firefighters, although further research is required to understand the scale of the condition in UK personnel, as well as the implications for performance and well-being.

2.6.2 Line of duty firefighter deaths and physical injury rates

As well as psychological injury, there is also a risk of physical injury whilst on duty. In the UK, recently published data from the Fire Brigades Union in November 2008 found that at least 122 firefighters have died whilst on duty in the UK from 1978 to November 2008, with around two-thirds (82) of these classified as operational deaths. In total over half of all operational deaths (44) are attributed to fire-related incidents, of which nine were caused by burns, six to being overcome by gas/smoke, five from burns and being overcome by conditions, 20 were unspecified, and the four between 1978-1980 had no cause described.

Since 2003, at least 22 firefighters have died while on duty, with at least 13 of these killed at fires, the worst 5- year period for more than 30 years. This is a significant change in the downward trend that had existed until the turn of the century, where there were no recorded fire deaths in the UK between February 1996 and October 2002. This means that from 1978 to 2007, there was an average of 4 on-duty firefighter deaths per year, or one on-duty death in the UK every three months for the last 30 years. In 2005 alone, 359 firefighters suffered a non-fatal accident, of which 57% were accounted for as personal injury (National Statistics, 2007). However, these statistics are significantly less than in the USA, where fire departments nationally respond to around 1.8 million fires per year, or around four fires per minute. Of the 1.1 million career and volunteer firefighters within the USA, each year more than 100 firefighters die in the line of duty and over 80,000 are injured (Karter & Molis, 2009). During the 11 year period from 1995-2005, the US bureau of labour statistics reported 1,006 line of duty deaths, with firefighting having the highest occupational death rate for sudden cardiac events. Kunadharaju et al. (2011) state that the fatality rate for US firefighters is three times worse than the general working population, and that the number of fatalities have not improved in the past 25 years, and have actually been trending upwards for the past decade. In research examining firefighting and SCBA injuries, a report examining the previous ten years of firefighter injuries states how firefighters are twice as likely to die in a structural fire today than they were 25 years ago (Bernzweig, 2004), with Austin et al. (2001) stating that the largest category of non-fatal firefighter injuries in the US is due to contact with flames or smoke (39% of all injuries).

2.6.3 Injury triggers

As well as the culture of bravery and masculinity that is traditionally associated with firefighters (i.e. Delsohn, 1996), researchers have spoken about a ‘tolerance of risk’ that is widely accepted by firefighters and members of the public in their community, whereby extreme individual efforts and getting the job done by any means are expected by the public (Kunadharaju et al., 2011). These researchers describe how a ‘normalisation of deviance’ occurs, whereby certain risks become so commonplace that their significance is diminished to the point where they are accepted as normal and essentially immutable. Over time this risk acceptance is increased as additional and more severe risks become normalised and accepted. For example, it has been noted by fire service leaders that the reasons firefighter injuries have not changed over time despite the numerous safety programmes and practices that have been implemented is that firefighters' beliefs, attitudes, and behaviours regarding safety have not changed in recent years (Kunadharaju et al., 2011).

Firefighters are asked to respond to emergency incidents that often challenge their physical and mental capabilities, and as a consequence of this a firefighter's exposure to these dangerous situations has made their risk of a fatal accident three times greater than for other workers (Clark & Zak, 1999). Adrenergic surges caused by unpredictable and stressful bursts of high intensity is claimed to trigger acute cardiovascular disease events. In the USA, although fire suppression or extinguishing activities only account for 1-5% of annual professional time amongst firefighters, fire suppression accounts for over 30% of coronary heart disease deaths, giving firefighters undertaking fire suppression a relative risk of 10-100 times greater than undertaking non-emergency activities (Kales et al., 2009). Similar results have also been reported by an earlier examination of firefighter deaths resulting from coronary heart disease by Kales et al. (2007) who found that fire suppression activities resulted in the greatest risk of death to firefighters (12.1–13.6 times as high) when compared to non-emergency duties.

In response to 23 firefighter fatalities in the USA between 1979 and 2001, Mora (2003) researched the factors that were found to lead to firefighter fatalities during structural fires. Described as the loss of direction due to a lack of vision, 'firefighter disorientation' was found to usually precede firefighter fatalities, and was also attributable to firefighter injuries that include smoke inhalation, carbon monoxide poisoning, burns, and traumatic injuries. In the incidents studies by Mora (2003), in 100% of the incidents firefighter crew integrity was lost (with over half of the firefighters becoming separated during evacuation from the building), firefighters became disorientated, and all were in an enclosed structure with prolonged zero visibility. This has led to Mora (2003) describing a 'disorientation sequence' (presented in figure 2.7), whereby a firefighter arrives at an enclosed structure with smoke visible, before conducting an aggressive interior attack on the fire (wearing SCBA), and encountering prolonged zero visibility due to smoke and difficulties locating the source of the fire. The SCBA team will then become separated or tangled hoses are encountered, before becoming disorientated as a result of exceeding their air supply or being caught in backdrafts or flashovers. If the firefighters cannot then be located the outcome is typically fatality or serious injury.

The disorientation sequence demonstrates the number of environmental (i.e. internal conditions), and personal factors (air supply management and search techniques) that can lead to injury and must be managed during structural fires. Therefore, the identification of the methods of reducing any physical or psychological demands present when the firefighter is undertaking firefighting activities within an enclosed structure with limited visibility may reduce the potential for team separation or confusion to occur and negate the probability of disorientation.

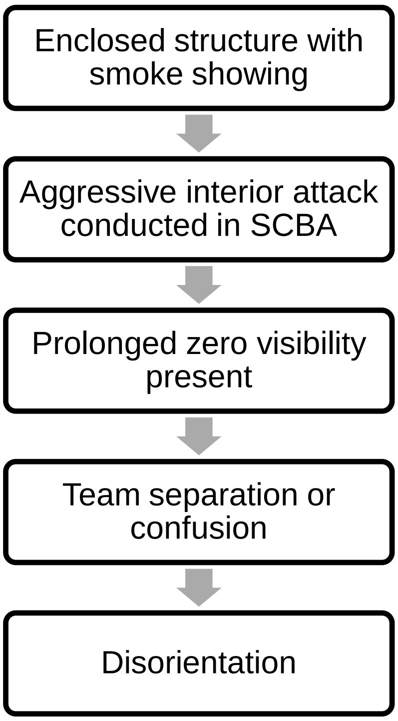

Figure 2.7. Firefighter disorientation sequence that typically leads to firefighter fatalities or serious injuries when wearing SCBA at structural fires (Mora, 2003).

2.6.4 Costs of firefighter deaths and injuries

From an economic perspective, the death and injuries of firefighters are expensive and inconvenient, with Nevola (2003) stating that on-duty injuries account for the loss of an average of nine-shifts per firefighter. A report into the economic consequences of firefighter injuries in the US by the Department of Commerce (2004) estimates that the cost of firefighter injuries is in the region of between $2.8 billion and $7.8 billion dollars. The direct costs of firefighter injuries (costs that are a direct result of the injury) include:

- Lost wages of the injured firefighter that exceed disability payments
- Overtime wages, above the cost of the injured firefighter's wages, to fill in for the firefighter
- Medical costs
- Costs of psychological counselling for pain and anguish suffered by the firefighter, the firefighter's family, and the firefighter's co-workers
- Time spent by the firefighter, supervisors, and others in investigating the incident and writing the injury report
- Cost of outside investigations
- Disability/retirement income (when firefighters cannot return to work for years, or retire on disability short of a normal career length)
- Litigation costs

Meanwhile, the indirect costs identified by the report include:

- Additional staff sent to firegrounds for preventing and dealing with firefighter injuries (rapid intervention teams; safety officers)
- Cost of firefighter PPE
- Maintenance of PPE (including cleaning and inspecting protective suits after each use)
- Cost of training for firefighter safety
- Administrative costs of insurance
- Cost of safety officers
- Union time and fire management time spent on negotiations

The implications of greater understanding and implementation of research into factors that may improve firefighter wellbeing has a broad scope. This section demonstrates the large numbers of other staff and agencies who become involved following firefighter injuries, with areas ranging from shifts lost, to the costs associated with legal, medical, and financial practices.

2.7 Literature review summary

Firefighters are required to possess a wide range of skills that must be sufficient to meet the demands of the task, despite the large number of factors that have the potential to influence psychological and physiological function and impact upon their performance when wearing SCBA (see table 2.1 for a full list of these factors). In addition, they must be able to work effectively in a team, communicate clearly, and possess problem solving and decision making skills. They must also attain high levels of physical fitness including $\dot{V}0_{2max}$ levels and strength. The work they carry out is varied and subject to a wide range of environmental factors including novel environments, extremes of heat, and high time pressure compounded by moral pressure from bystanders to save life.

The scope of current research suggests that not enough is understood and not enough is currently being done to address issues critical to firefighter performance, on scene safety, and long term well-being. In general, recent research by Weston (2012) has suggested that there is currently little rigorous academic study of situations considered extreme or unusual despite the number of people that encounter such environments. Firefighter line of duty deaths and injuries are high despite the advances in personal protective equipment and incident command training. One of the recommendations from the Fire Brigades Union (FBU, 2008) is the urgent need for centrally issued, substantial, safety critical national guidance on the issues arising from recent fatalities, including guidance for initial attendance, risk assessment, incident command, breathing apparatus, compartment fires, high rise fires, backdraught and flashover, and heat stress.

Table 2.1. Factors influencing physiological and psychological function associated with firefighters' performance when wearing SCBA

Factors affecting physiological function	Factors affecting psychological function
Firefighter fitness and strength attributes	Coping
Physical demands of wearing personal protective equipment (PPE)	Changes in cognition during firefighting tasks
Heat stress and rises in core body temperature	Stress
Hydration status	
Heart rate and blood pressure reactivity	

Physiological research has established that the weight of wearing SCBA and personal protective equipment is around 23kg (Marshall, 2003), and is likely to lead to increases in heart rate, blood pressure, and core body temperature in the firefighter during firefighting tasks (Rayson et al., 2007). A less comprehensive body of literature considering the psychological demands of firefighting suggests there is a likelihood of degradation in cognition during firefighting activities, although this is subject to methodological difficulties in identifying the specific cognitive constructs to be measured. To date, evaluation of the stress responses and coping strategies of firefighters have been primarily concerned with methods relating to chronic on-duty stressors, responses to one-off large scale incidents, or those to prevent the onset of post-traumatic stress disorder symptomology. Accordingly, the ability to cope with the acute demands of frequently encountered tasks are yet to be fully considered. Firefighters will be subject to a series of stressors each time they are called-out to an incident, with their reaction to these subject to their specific appraisal of the task or environment.

Therefore, the overall aim of this thesis is to establish the occupational stressors considered most demanding by firefighters and explore the coping strategies that lead to effective management of physiological and psychological stressors by these personnel at the fire scene. The detailed aims of this thesis are described in section 1.1.

Chapter 3

Stressors and coping strategies of UK firefighters during on-duty tasks

"The only one who can really understand your attitudes and feelings is the guy next to you. We provide psychological first aid and reassurance to each other. All a buddy needs is the reassurance of someone else nearby. The people in our unit always talk afterwards, trying to learn from our mistakes. We try to make it easier on one another."

Fullerton et al. (1992, p.374)

Chapter 3 – Stressors and coping strategies of UK firefighters during maximal physical effort tasks

3.1 Introduction

Prior to understanding how emergency service personnel develop and apply coping strategies or the impact of tasks upon physical and psychological responses, the first stage was to identify the specific tasks that are considered stressful and demanding whilst on duty. It is known that incidents attended to by the fire and rescue service often involve daily and unavoidable exposure to extreme physical demands and psychological stressors. These stressors may include factors such as exposure to dead bodies and prolonged attendance at traumatic events that often involve novel or infrequent problems, extreme time pressure, and high stakes (often with lives hanging in the balance) (Salas et al., 1996). As a result, the recognition and management of these demands is not only of importance to facilitate firefighter performances during an incident but is also essential for ensuring the health and welfare of the firefighter, those around them, and the persons in need of rescue. Regehr et al. (2008) have identified a number of the demands present at the scene of operations. The researchers state how much of the work performed by emergency service workers occurs under conditions of acute stress following an initial response to a scene with little or no prior knowledge about what they are about to encounter. The weather and terrain may further impede rescue activities, whilst the availability of assistance from others and the reactions of bystanders can also be unpredictable. As a result, these factors may combine to increase or decrease the possibility of success, and even the potential risks to the responders on the scene.

3.1.1 Occupational Stress

A number of physiological and psychological stressors may be present during the firefighter's working routine. Berger (2002) describes how firefighters may become stressed by their own station environment, their protective gear, their officers and leaders, current management styles, co-workers, and the stress of leaving their families and loved ones during disasters. During operational incidents, common psychological stressors may include the location and retrieval of deceased persons, maintaining high levels of mental acuity, and decision making with limited information within a high time-pressure situation. Additional social considerations include the moral pressure from bystanders and victims to perform rescues in dangerous environments, individual responsibility to ensure the wellbeing of fellow team-members, and calming / reassuring persons who have been involved in the incident (Young, 2007).

Despite the presence of these stressors, previous research investigating the demands placed upon firefighters has predominantly looked at the quantitative aspects of physiological responses to training environments. The main focus has been upon the relationships between variables such as increased heart rate (Holmer & Gavhed, 2007), increases in core body temperature (Angerer et al., 2008), and cardio-respiratory fatigue (Marshall, 2003) on firefighter performance. Studies examining psychological response to task related stressors have primarily looked at factors that may dispose individuals to post-traumatic stress disorder at exceptional one-off events (Beaton et al., 1998).

The impact of stress upon firefighting performance is complex and yet to be fully understood, with researchers stating that there is currently disparity surrounding the concept of stress due to its exceedingly broad and poorly defined nature (Berntson & Cacioppo, 2004). As a result, the psychological demands that must be managed by firefighters during periods of intense physiological activity, as described in the literature review, and the potential effects upon firefighting performance in both training situations and real life incidents still remains unknown. The specific environments and role-related tasks considered by UK firefighters to be the most stressful, the factors that make them stressful, and the frequency with which they are encountered have yet to be investigated by researchers.

Carley et al. (1993) examined the benefits and disadvantages of exposure to disaster scenarios and the requirement to make decisions under stress. They describe how typically decision-making skills can be enhanced or hindered by human physiological responses to disaster, leading to the possibility of the individual ‘rising to the occasion’ where they gain confidence in and commitment to a course of action during an incident, or ‘crumble under pressure’ and badly underperform. Stress may also serve an adaptational function that can mediate and energise behaviour by allowing the individual to channel physical and mental resources towards a task (Vallerand & Blanchard, 2000). Alternatively, the individual may become hesitant or ‘immobilised’ by the situation, leading to reduced creativity, in particular in terms of considering potential solutions. Studies have demonstrated that in emergency workers stress can result in reductions in correct decision making by at the emergency scene (Mandler, 1993), with Regehr et al. (2008) suggesting that acute stress situations can lead to performance deficits in emeregency personnel, although the specific impact of stress during ‘critical’ functions remains unclear.

3.1.2 Coping

One of the key findings within stress research is the notion that not everyone exposed to stressors will react to the factors in the same way. Not everyone will suffer from declines in performance when experiencing stress, and some people may actually perform better under stressful conditions. The ability of the individual to survive and flourish is considered to be strongly associated with their ability to manage stress effectively, and one of the mechanisms that allow people to manage stress effectively is coping (Nicholls & Thelwell, 2010). Coping is considered more complex than simply the type and context of the stressor encountered, and there are a wide range of contributing factors that can influence the response of the individual. These factors are thought to include personality, knowledge, coping skills repertoire, skill level, fire service specific culture, motivation, gender, social support, experience, and environmental demand in addition to personal meaning, appraisals, and outcome efficacy (Crocker et al., 2010).

At present there is no definitive model or understanding of the stress and coping of firefighters and emergency service personnel. Within research examining coping in the fire and rescue service, there is a need to determine what firefighters, crew managers, watch managers and incident commanders are required to cope with, the factors that determine the selection of specific coping strategies, and how to conceptualise the outcomes of coping. However, there are extensive examples and usage across related disciplines. The research into sport and exercise psychology has developed from earlier research from the 1960’s and 1970’s focusing upon coping with issues such as illnesses, medical conditions, bereavement, and combat stress in the military and burnout (Richards, 2012). The key questions raised by research examining stress and coping in sport, such as what athletic performers have to cope with, the different types of coping responses being used, the types of coping that are better than others, and how athletes can be helped to perform better (Richards, 2012) are closely aligned to the questions raised by this research in firefighters. Research on athletes is particularly applicable to firefighters given the similarities that can be applied between these two professions. For example, in both professions the outcome for the individual may rest upon a performance lasting only seconds but has been developed through hours of training. Demands of both occupations may also include operating efficiently within a team, performing effectively under conditions of heat and physical fatigue, rapid decision making under stress, coping with social and observation stress, and maintaining close support networks.

Coping can be described as any changes in thoughts or behaviours made to manage the perceived demands of a situation (Lazarus & Folkman, 1984). One of the most established models of stress and coping in occupational and sport settings (Nicholls & Polman, 2007) is the transactional approach proposed by Lazarus and Folkman (1984) (a review of alternative models is discussed in chapter 2). In this model, stress is seen as a relationship between the person and the factors within their environment that are potentially dangerous to themselves. It is based upon three factors or appraisals that will determine the extent to which the transaction between the person and the environment is seen as stressful. During 'primary appraisal', an individual will evaluate what is at stake and judge the encounter as either 'irrelevant', 'benign-positive' or 'stressful'. Following the individual's primary appraisal of their environment, 'secondary appraisal' will take place. At this stage, the individual will consider what resources are available and as a result what can be done to deal with the situation. This will be based upon the individuals' personal goals and their perceptions of the potential benefits or consequences of a particular coping strategy. Despite the names attributed to these stages, both primary and secondary appraisals are thought to occur relatively instantaneously (Lazarus, 1999). Finally, during the third stage, known as 'reappraisal', individual adjustments are made based upon new information gained from the environment or from themselves during the event.

In order to regulate the emotions arising from the interaction, the individual will seek to manage the internal or external demands that are appraised as exceeding the resources available to the individual (Lazarus & Folkman, 1984) by implementing coping strategies that match the specific situation faced. It has previously been suggested by Folkman and Moskowitz (2004) that a primary reason for studying coping is that researchers believe that they will be able to identify effective and ineffective coping that will then help in the development of theory-guided coping interventions. This is despite the process being embedded in a complex, dynamic stress process that will involve the individual, their environment, and the relationship between both of these factors (Folkman & Moskowitz, 2004).

Any coping undertaken by an individual is described as being in response to the demands of the specific environment, and also by the personal preferences of the individual (Folkman & Moskowitz, 2004). This coping will include resources that are both available and perceived to be available, with Sarason et al. (1990) stating that it is the perception of availability of interpersonal resources rather than the actual resources available that is most closely related to how people deal with stressors. Coping responses include the utilisation of a wide range of cognitive, affective and behavioural efforts to manage threatening events (Lazarus & Folkman, 1984), and in the transactional model can take the form of either a 'problem' or 'emotion' focused coping strategy.

3.1.2.1 Problem and emotion focused coping

As discussed in detail in the literature review, in a problem focused approach, attempts are made to modify or minimise the stressors or situation (Lazarus & Folkman 1984). This direct action may also include 'chunking' or breaking the problem down into more manageable parts, seeking information and considering alternatives. Emotional focused approaches meanwhile, utilise mechanisms such as positive reappraisal, acceptance, and denial to moderate the negative emotions being experienced and minimise the stress reactions without actually addressing the cause of the stress (Lazarus & Folkman 1984). More recent studies, such as Compas et al. (2001) have expanded this area to also include relaxation or meditation, and wishful thinking. An additional layer of complexity is the fact that the notion of seeking emotional support can be considered both a problem and emotion focused strategy, as attempts may be made to find information from others about the stressor (problem focused) and seek emotional support from others or to seek justification for one's actions from others (emotional focused) (Thoits, 1986).

To enable the firefighter to successfully manage the multitude of demands placed upon them at operational incidents, the individual must utilise a number of coping strategies, yet research into this area is also limited. At present, one of the only indicators that coping is taking place in the fire service is the 'healthy worker' effect (Beaton et al., 1999). According to these researchers, length of service can be considered a useful way of measuring coping effectiveness as any firefighters who have failed to find or utilise effective coping mechanisms to deal with occupational demands would leave the fire service. According to the most recent statistics, in 2008 only around 5% of the UK firefighting workforce had left in the previous five years (Communities and Local Government, 2008) suggesting the potential existence of effective coping strategies and mechanisms currently being utilised by a high percentage of operational firefighters.

Due to the limited amount of research related specifically to coping in the firefighting community, as was the case with stress, it is necessary to draw upon related disciplines to gain a fuller understanding of coping. Again, the field of sport psychology offers the most appropriate starting point. The ability to cope with stress through means perceived as effective within sport can be considered to be based upon the degree to which a coping strategy or combination of strategies are effective in alleviating the negative emotions that arise during stressful events (Nicholls & Polman, 2007). There are instances within the realm of sport in which athletes have had to cope with physical and psychological demands that could be considered similar to firefighting scenarios. Although the wider stress and coping research has typically focused upon the long-term benefits of coping such as health, mood, satisfaction and well-being, the inclination of sport researchers has been to focus instead upon acute pressures in competition (or real-life incidents in the comparable example of firefighters). Within this specific context, coping effectiveness is described by Park (2000) as being able to lessen anxiety, activate arousal, or both, for the purposes of maintaining optimal performance. In the current study, this is accepted as the most appropriate definition within this research for firefighting environments due to the emphasis upon operational performance ahead of other facets such as applied learning or reasons for leaving the fire service.

Despite researchers such as Pensgaard and Duda (2003) stating that there is a tendency to label problem focused coping strategies as adaptive and emotion focused strategies as maladaptive (Carver, Scheier & Weintraub, 1989), this is not often the case when coping with acute stress in competitive sport situations. For example, in order to deal with sports stressors such as ‘injury’, ‘mental error’ and ‘physical error’ (Nicholls et al., 2006), there were very few strategies perceived by athletes as being highly effective, with only increased effort, increased concentration and positive reappraisal stated by participants as being effective. The researchers suggest that when a stressor is controllable people should employ problem focused methods as a strategy designed to influence or alleviate the stressor. However, when a stressor is not controllable an emotion focused strategy would be of most benefit since attempts to change the stressor would not make a difference (Nicholls et al., 2006). It would be interesting to determine if this association between control and choice of coping strategy is also demonstrated outside of sporting contexts, and specifically within the emergency services.

Therefore firefighters may be expected to demonstrate a tendency to utilise a combination of both methods during coping, with early studies outside of sport settings demonstrating this to be the case in over 98% of middle aged men during a stressful encounter (Folkman & Lazarus, 1980), and in an average of 96% of college students during a stressful examination (Folkman & Lazarus, 1985). In sports environments, Richards (2012) notes that athletes have reported using different coping responses over time and situations and different strategies are used in combination and applied flexibly to a stressor.

3.1.2.2 Career span coping

The issue of measuring the development of coping across a career or time span is another area that has been yet to be researched in firefighters, but there are limited examples of lifespan coping research in sport settings with elite athletes (i.e. Hoar & Evans, 2010). Career span (or lifespan) coping can be considered to be the re-organisation that an individual's coping skills undergo to produce further unique coping actions that serve a specific coping function (Skinner & Zimmer-Gembeck, 2007). Typically, athlete coping across the lifespan has been measured in one of three ways: age periods (such as school age, adolescence, student-athlete, early adulthood, middle age, and older adulthood); the comparison between studies that have utilised samples constrained to a specific development stage; and maturation-related differences in coping (i.e. Nicholls et al., 2009).

Despite the lack of information upon the re-organisation of coping skills in firefighters, sport psychology research utilising athletes suggest that there are coping traits found at certain age spans that may be compared to equivalent ages in firefighters to provide a general overview of potential coping processes at each stage. In older adolescent athletes (aged 18-23 years of age), coping is considered to be highly adaptive, with athletes in this age range using a wide range of coping strategies. However, the coping strategies developed at the older adolescent stage are considered to be susceptible to individual differences that are influenced by person variables (such as gender and confidence), personal resources (including social support providers), types of environmental stressors, and the temporal phase of the stressful event. As a result, the diversity and breadth of coping strategies is still being developed in this population (Hoar & Evans, 2010).

The coping strategies utilised during the 'early adult' athlete level (ages between 23-32 years) have attracted an extensive amount of research from sport psychologists in a wide range of sports, and competitive status. Group analyses of this research indicate that management of stressors by athletes competing in international- level events typically includes the problem focused and emotion focused strategies of acceptance, increasing effort, planning, imagery, and confidence in self (Thelwell et al., 2007). Middle aged adult sport participants (aged 35-59 years of age), such as recreational marathon runners, have been studied less extensively than those in early adult age, although research has found athletes at this stage to use a range of coping strategies that were both behavioural and cognitively managed (Buman et al., 2008). Finally, there was not found to be any published studies of older adulthood athletes (aged 60+), despite the increasing popularity of masters level competition (such as the World Masters Games) (Hoar & Evans, 2010). This is unfortunate as it would be of interest to apply a sport model to understand the coping strategies of firefighters who are still on operational duty at this age.

3.1.3 Aims of chapter 3

Any coping-related interventions with the potential to reduce or manage the environmental demands of an operational incident would form an invaluable part of a firefighter's response in emergency situations. Therefore there were three specific aims of the current study:

i. To identify the most common occupational stressors that exist in English firefighters.
ii. Establish the specific coping strategies that are utilised to successfully manage these demands, using Lazarus and Folkman's (1984) transactional approach as a theoretical framework for understanding coping.
iii. Explore the stressors and usage of coping strategies at specific stages of a firefighter's career.

3.2 Method

3.2.1 Participants

In the first phase of the study, three separate focus groups were conducted involving 21 male, full time personnel based in the same fire and rescue service, and considered fit for operational duty. 15 participants were firefighters, and six were in the supervisory role of crew manager. Length of operational service ranged from three to 31 years (mean 11.9 years).

The second phase consisted of semi-structured interviews conducted on a one-to-one basis with six participants, four currently in a firefighter role and two who were crew managers. All participants were again male, full time personnel based in the same fire and rescue service as the focus group participants and categorised into one of three groups according to their length of operational service: early career (< 5 years) (n = 2), mid-career (~15 years) (n = 2) or late career (~30 years) (n = 2). None of the interview participants had previously taken part or were aware of any of the findings from the focus groups. Like the focus group participants, they were all considered fit for operational duty and were all serving fire service personnel.

Both focus group and individual interview participants were given a code as firefighter (FF) or crew manager (CM) with the suffix of how long they have served, and their operational role. For example, a crew manager with 17 years' service was given the participant code CM17. There were no participants with identical years of service. This was also the code that participants could use to withdraw all of their information from the study at any time. All participants worked a 48-hour period of duty consisting of two day shifts from 0900-1800 hours followed by two nightshifts from 1800-0900 hours and four days off.

Prior to involvement in the study all participants read a participant information sheet, and after a cooling off period of seven days, signed an informed consent form approved by Northumbria University School of Life Sciences ethics committee. There were no exclusion criteria for either part of this study.

3.2.2 Pre interview preparation

In keeping with Mooney's (2002) recommendations, the process of 'bracketing' took place, whereby to eliminate the potential for either bias or prejudice during the data collection or analytical data phase, the lead researcher reflected upon his own experiences and documented this information prior to starting the data collection process. As the researcher was also a career firefighter, it was essential for him to be aware of his own pre-conceived notions and the meanings that he had attributed to his own experiences. This would enable the analysis of informants' data to remain as neutral as possible.

3.2.3 Procedure

For both focus group and individual participation, a letter detailing the nature of the study and requesting voluntary participants was sent to the station managers of the four busiest fire stations within the North-East region. Participants were informed that the aim of the study was to examine the stressors that they experience, the situations in which the stressors were encountered, and the strategies and techniques that were used to manage these stressors.

This information was then displayed on the notice board within the station, with instructions for interested parties to inform their watch manager. The contact details (e-mail and telephone) for the lead researcher, who could provide further information, were also provided. The watch manager would then inform their station manager who provided a list of potential participants to the lead researcher. Interested parties were then sent a letter informing them of the rationale behind the study and the benefits of taking part. The researcher allocated participants to focus groups based upon the station they were attached to at the time of interest. Participants recruited to take part in individual interviews were contacted to agree an appropriate interview date.

Data for both the focus groups and interviews was collected in the participants' own fire station, at the request of the participants. Participants were also asked to select the time most convenient for themselves free from professional commitments, family responsibilities, or anticipated periods of high noise and distractions. Data was collected while personnel were off duty.

When taking part in the focus groups and individual interviews, the participants were greeted by the lead researcher, given a reminder of the procedure detailed in the participant information sheet, and asked to read and sign an informed consent form. At this point participants were also encouraged to, and given the opportunity to ask any questions and were provided with the aims of the study. Participants were reminded of their right to withdraw at any time without having to provide a reason, as well as reassurance that there were no correct or incorrect answers that could be provided. At the conclusion of the data collection, participants were given a debrief sheet and contact details for the fire service trauma support counselling service, which they could contact should they feel the need to talk to a professional as a result of any distress arising from talking about events during the study.

3.2.4 Data Collection

Given the complexity of the coping process and due to the current lack of understanding within the fire service as to the exact on-duty stressors experienced in the UK and a lack of validated data collection methods within this population, a primarily descriptive and open-ended exploratory method was employed with the aim of directing future research. This included the use of focus groups and individual interviews that are considered valuable when looking at variables that cannot be controlled or when looking at variables that have not been previously considered in research (Crocker et al., 2010). A key strength of these approaches are that they afford the researcher the opportunity to explore complex responses that are impossible to access via questionnaire and allows the researcher to study the whole, subjective experience of the participant by examining the way people perceive, create and interpret the firefighting environment (Cote et al., 1993). Further guidance was also provided by Mooney (2002) who conducted qualitative research into stress and coping, and has suggested that the use of both recapitulation (taking the participant back to the beginning of the experience) and periods of silence (encouraging them to tell the story in their own way) are effective techniques when conducting such methods.

All of the focus groups were conducted by the lead researcher, and all information was recorded via digital voice recorder (Olympus VN-500). Participants took part on one occasion only, with each of the sessions lasting around 40 minutes.

The individual interviews focused upon the validation and expansion of general themes raised by the focus groups, and were also utilised to address the issue of socially desirable responses from participants taking part in the focus groups. A semi-structured approach was used, with a number of open questions used to elicit extended responses as this allowed for a flexible approach which could be adapted to the individual under study and to various research problems (Cote et al., 2003).

All of the individual interviews were conducted by the same researcher, and all information was recorded via digital voice recorder (Olympus VN-500).

Participants took part on one occasion only, with each of the sessions lasting around 20 minutes. A copy of the focus group question schedule can be found in appendix B, and individual interview question schedule in appendix C.

3.2.5 Treatment of data

Tape recordings were individually transcribed verbatim into electronic written format. Of importance during this stage was the removal of any information of a legal or sensitive nature, such as specific names, dates, addresses, or details of operational incidents that could identify any persons (either emergency service based or victim) present. As per guidelines by Cote et al. (1993) regarding the organisation and interpretation of unstructured data, a two stage process of analysis was employed for both the focus group and the interview data:

i. Creating tags: this involved dividing the text into segments that are comprehensible by themselves and contain an idea, episode or piece of information (Tesch, 1990).

ii. Creating categories: tags were listed and compared to the tags initially derived, first by the researcher and then involving members of the supervisory team. This involved labelling these cluster of tags with similar meanings to ‘re-contextualise’ the information into categories that then serve as a preliminary organising system.

The use of a peer review by someone familiar with the research is considered to be advantageous as the reviewer can provide support, play ‘devil’s advocate’, challenge the researcher’s assumptions, push the researcher to the next step methodologically, and asks hard questions about methods and interpretations (Lincoln & Guba, 1985). Most importantly, by seeking the assistance of a peer de-briefer, credibility can be added to the study (Lincoln & Guba, 1985). For this reason the decision was made to use peer debriefing as part of the analysis process by utilising one of the station managers who had previously been approached for recruitment of participants.

Emerging themes were then classified as descriptive or higher order categories. In order to ensure validity of the data, procedures recommended by Sparkes (1998) were utilised and adapted for the needs of the sample. This included three occupational experts (one experienced watch officer; a training school instructor; and a counsellor) examining the raw data independently and holding structured meetings to discuss observed similarities and differences, as well as exploring multiple interpretations and discrepant findings, until a unanimous consensus was obtained.

3.3 Results

3.3.1 Overview

The primary focus of this study was to identify the specific stressors associated with firefighting tasks, and to examine the coping responses utilised to manage these demands. The results section is presented in three parts; firstly, the most common stressors, the frequency of experience of these stressors, and the common responses of firefighters are presented. Secondly, the key coping strategies utilised by the firefighters to address these stressors are discussed. Finally, the coping experiences of firefighters at each of the three career stages are compared and described.

3.3.2 Stressors

Analysis of focus group quotations revealed an emergence of 121 responses describing unique stressors that could be grouped into 17 categories and further grouped into five higher order categories. The higher order categories were: physical demands of firefighting, risk of injury, cognitive demands of firefighting, driving, and dealing with fatalities. Figure 3.1 provides an overview of the frequency of these stressors by category and subcategory.

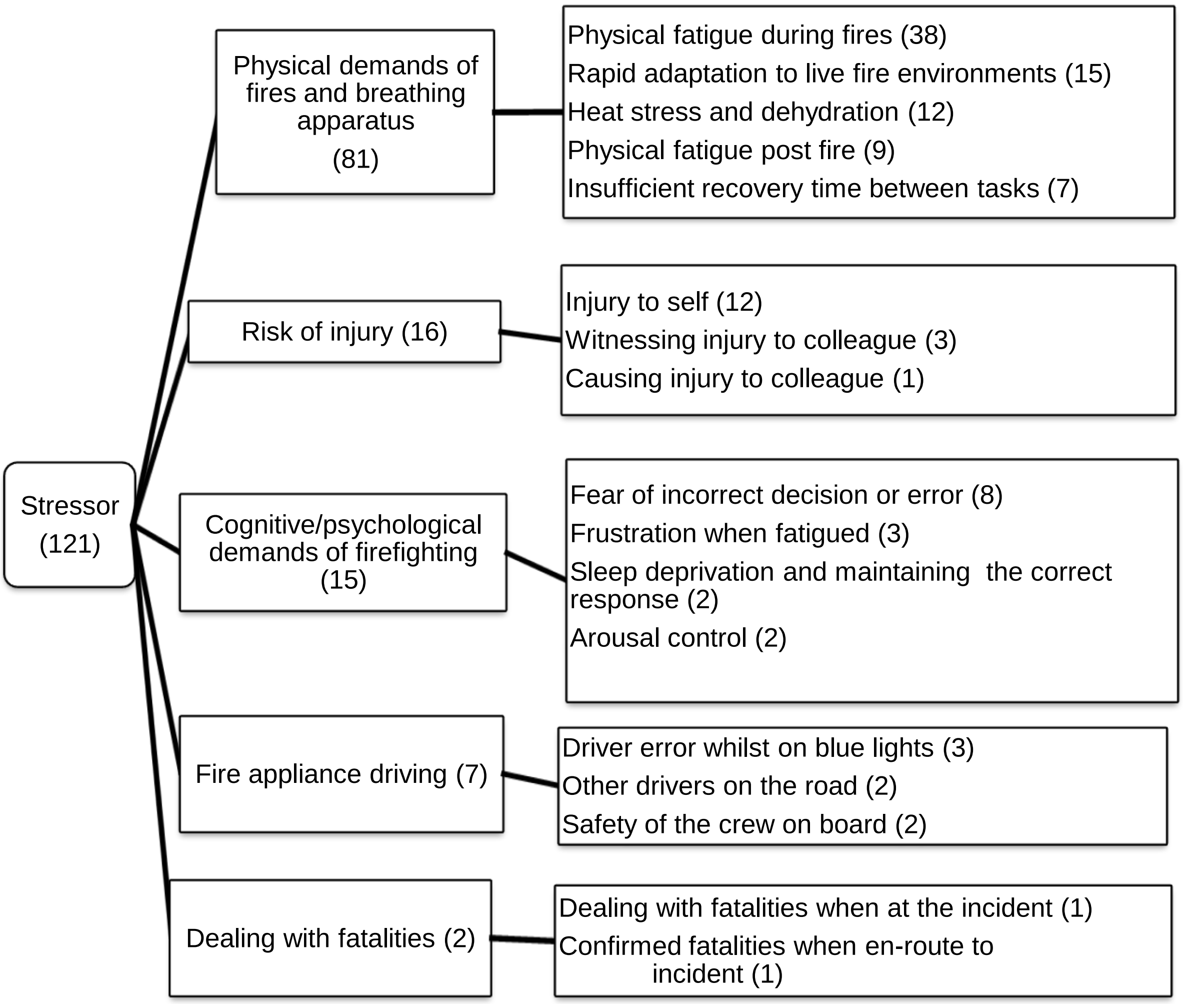

Figure 3.1. Stressors and (number of times reported) by firefighters in three focus groups

3.3.2.1 Physical stressor demands

The most common stressor reported by participants was the physical demands of fires in both training and real life, including incidents in residential premises (i.e. houses, bungalows and flats including high rise towers), marine locations (such as ships and docks), and commercial buildings (such as factories, storage units and office blocks) whilst wearing self-contained breathing apparatus (SCBA). This will start to occur almost from turnout, as described by FF31:

> *“you’re under a certain amount of stress from turnout on your way to a house fire persons reported because you know that there is a big chance that you will have to go in there and work very hard physically, and pull them out and that’s probably the most stressful thing”*

The physical demands stressor accounted for over two thirds of all responses (67%) by the firefighters and crew managers taking part. Sub-classification of these physical demands of fires and SCBA use included the onset of physical fatigue during such incidents, the rapid adaptation that must take place within the fire environment (from an almost stationary level of activity on station to near maximal levels of effort when arriving at the fire scene), physical fatigue experienced after the incident, heat stress, and self-perceived dehydration considered to impact upon their performance at the incident. Additional stressors involved being physically fatigued after wearing SCBA in a fire and being aware that they may be deployed to another incident even though they may not have fully recovered from the physical and psychological demands of the previous tasks.

The most common of the physical demand stressors (cited 38 times by participants) was the physical fatigue that occurred during SCBA tasks. Specifically, fatigue can be induced by a number of factors including wearing the PPE, weight of the SCBA set, carrying heavy equipment (such as breaking in gear and hose), as described by CM10:

> *"most physical stress on the body involves fire, every time, nothing we do in this job even compares to actual being in a real working fire. The physically demanding elements are mostly manual handling related, equipment for firefighting such as charged hose, cutting equipment, BA sets, and high rise equipment."*

Often all of these physical demands are present at once, as identified by CM19:

> *"it's all physically demanding work, and often it will be an amalgamation of strength, stamina and fitness levels because of the equipment. If you're not physically fit you're gonna suffer...if you're working in the heat and doing some physical graft it won't take long until you're suffering a fair bit"*

Rapid adaptation was the next most cited physical stressor (mentioned 15 times) and was based upon the firefighter going from a sedentary position to one of extreme time pressure and multiple tasks upon arrival, in particular during house fires with persons trapped, such as stated by FF12:

> *"at a confirmed persons house fire, everything's gotta be done at the double y'no, everything's gotta be done like yesterday…the work effort you're putting in you know you must be near your limits, if you're dragging someone out you feel yourself going down physically and just want to get out"*

Heat stress, although linked to physical fatigue, was considered as a separate classification within the sub-classification of physical stressors as participants often talked about the link between heat and dehydration opposed to fatigue. Key to this was the time taken for hot conditions to impact upon the individual, and seemed to exist regardless of the intensity of the work being conducted. FF9 mentioned a situation where his task was one of ventilation of smoke rather than saving life, yet:

> *"you don't even need to be doing much, just going in and coming back out in the heat will get you extremely drained and dehydrated. Any type of job that's hot fire whether you're doing hose reel management, actually firefighting, or whatever will just drain you"*

Given the physical demands that have been previously experienced (fatigue during the task; rapid adaptation; heat stress), the issue of post incident fatigue was often mentioned. This classification related specifically to the demands of the fire scene, such as when their initial task had been completed (such as rescue of life) but further unknown tasks may still be required. One of the problems identified by participants was the difficulty in training their bodies to be able to speed up recovery, in particular the inefficiency of gym based exercise to buffer the onset, as mentioned by CM19:

> *"fatigue comes down to the demands of the environment, not just fitness…if you spend an hour in the gym working that hard you don't get as tired as you do in a fire that's no-where near as long"*

3.3.2.2 Risk of injury

There second most common stressors cited by participants were related to risk of injury (13% of all stressor responses) including both injury to themselves and others in their team during incidents. This category is comprised of a combination of factors that included 'booby trapped' buildings that may pose a threat to the team, but also the risk to others' safety if they collapse from the physical demands during the task. FF29 talked about the physical and psychological factors that create a risk of injury stressor at a house fire:

> *"especially if you're in a particularly nasty job, you've gotta be able to get out, if you're trying to rescue someone and you end up being the rescued body then that's not good…you have to work together as a team and not do everything yourself because you won't be popular if they have to drag you out. Obviously you're apprehensive once you go through that door at a house fire because you don't know what's in there or who is in there, it can be quite nasty or even booby trapped."*

3.3.2.3 Cognitive stressors

Cognitive stressors (12%) were described as being present both prior to and during an incident, and almost all responses were related to the cognitive stressors they experience at breathing apparatus incidents and when firefighting.

Cognitive stressors were made up of four themes: fear of an incorrect decision when wearing SCBA at a fire, controlling frustration when fatigued at a SCBA incident, being able to provide the required response when sleep deprived on a night shift, and keeping emotions and arousal at self-perceived appropriate levels. Often the issue of required responses on a night shift can be influenced by the actions of that night but also the activity from the previous night's shift. FF29 talked about occasions where he had been turned out after having had a busy shift the night before:

> *"on a busy 15 or 16 hour nightshift mental fatigue will come into it by the latter stages, or even if you are not fully recovered and recuperated from the first nightshift, so a lot will depend upon how and when your body will cope. I think with only working two nightshifts you're mentally thinking 'I don't need to compensate', but you could be called out exhausted in the middle of the night on a relief and know you're gonna be there for 3-4 hours"*

In addition, FF7 talked about the difficulties in emotional control when he was around one year into service:

> *"you go in to the fire and allow yourself to remain emotionally and mentally detached but focused on the job, although when you're slightly younger your emotions just go up and up and up and then you can't maintain it and it drops off. There is high anxiety en-route since you don't know what you're going to, then it drops as you see the scene then rises rapidly again upon entry (in SCBA)."*

Fear of making an incorrect decision was multi-faceted, and based upon the consequences for themselves, other firefighters within their SCBA team, and the knowledge of the risk to a person trapped inside the structure in need of rescue. For example, FF29 discussed the link between frustration and decision making when wearing SCBA, in which the frustration stemmed from a combination of physical fatigue but also a slowing down of cognition:

> *"you have to make rapid and correct decisions or people will be in trouble. You get more and more frustrated as you get tired and struggle to think as clearly as you would like, and you have to calm down and cope a bit better than just going more gung-ho."*

3.3.2.4 Driving

The driving demands category (6%) was made up of three sub-categories that included making errors when driving under blue-light or emergency conditions, the unpredictable nature of other motorists and the public whilst driving on blue lights, and crew safety on board during this time. In the UK, fire appliance driving is not a dedicated role within the fire service, but instead is undertaken by personnel on the same watch who will take turns to drive, often decided by a rota produced by the watch manger, and within the focus groups, eight participants were drivers. FF6 describes the stress of driving on blue lights to an emergency scene and having to instantly switch on and know the route upon turnout, as well as being aware of the consequences of making an error in directions:

> *"if you're driving you have to instantly plan the route in your head when the bells go down cos you definitely wanna get there as quickly and safely as possible and it's not like you can stop and ask the public for directions. Sometimes this is made harder by the gaffer in the seat next to you telling you which way to go, or the others (firefighters) in the back shouting directions, or by having to follow the appliance in front. It's even harder if you're detached [covering another firefighters shift elsewhere] or going into another stations area"*

Other stressors reported included the responsibility for the crew on board, and vice versa. For example, FF19 had never been a driver but talked about the raised stress levels when en-route due to the lack of control they have:

> *"when I'm at an incident, I know that I am fully in control of what is happening around me, but when driving to a job my safety is in someone else's hands, and I know it is their job to get 12 tons of metal around crowded roads as quickly as possible"*

The final stressor in this category cited on two occasions was the actions of other motorists and the public when driving. FF9 mentioned having to often drive through the single lane road to get through the city centre:

> *"you're absolutely bombing and you think 'if just one person pulls out of this next junction…' sometimes drivers just freeze up in front of you as well. Although we are trained what to do they aren't and it is impossible to predict how they will react on the roads"*

3.3.2.5 Fatalities

Finally, the dealing with fatalities category (~2% of responses) was broken down into actually finding and dealing with the casualty at the scene, and also being turned out to an incident and being informed en-route by control via radio that there is a confirmed fatality already at the scene in need of retrieval. Unlike in previous categorisation of stressors that are considered greater at fires, the issue of fatalities led to a mixed response from participants. FF12 describes how there is often lots going on at a residential fire, where you will often deal with a fatality alongside undertaking other tasks such as extinguishing the fire. However there are occasions where the fire service are requested to attend an incident primarily to assist with body retrieval, which increases the demand of the task:

> *"mentally, confirmed fatalities in exceptional circumstances are the most stretching psychologically because you've actually got time to think and prepare for what you might see"*

This was an issue that was in contrast to FF9 who found that it was the lack of preparation that made the task difficult with fatalities;

> *"Going into a house fire and finding a fatality is more of a shock because you haven't got any time to prepare for it"*

3.3.3 Coping

In keeping with the theoretical model proposed by Lazarus and Folkman (1984), two broad coping themes consisting of problem and emotion focused coping techniques were utilised to evaluate and group the participants' responses to fires.

A general overview reveals that of the 90 coping strategies reported by firefighters, problem focused approaches comprised 45 (50%) of the total coping strategies quoted by participants. A remaining 30 (33%) of responses, mentioned were categorised as emotion focused, with the final 15 (17%) coping strategies grouped as both problem and emotion focused based upon the earlier recommendations of Thoits (1986). The following sections will discuss these broad coping themes in terms of their perceived effectiveness, situational usage and frequency. Figure 3.2 provides a breakdown of the coping function and subsequent themes.

Due to the frequency and likelihood of these incidents occurring, either in training or in real life, and the number of times reported as a stressor, strategies used by firefighters during fire incidents were examined in greater detail. These higher order areas were then broken down into first order themes including acceptance, avoidance, distraction, nutrition and experience, and further still into second order themes (see figure 3.2).

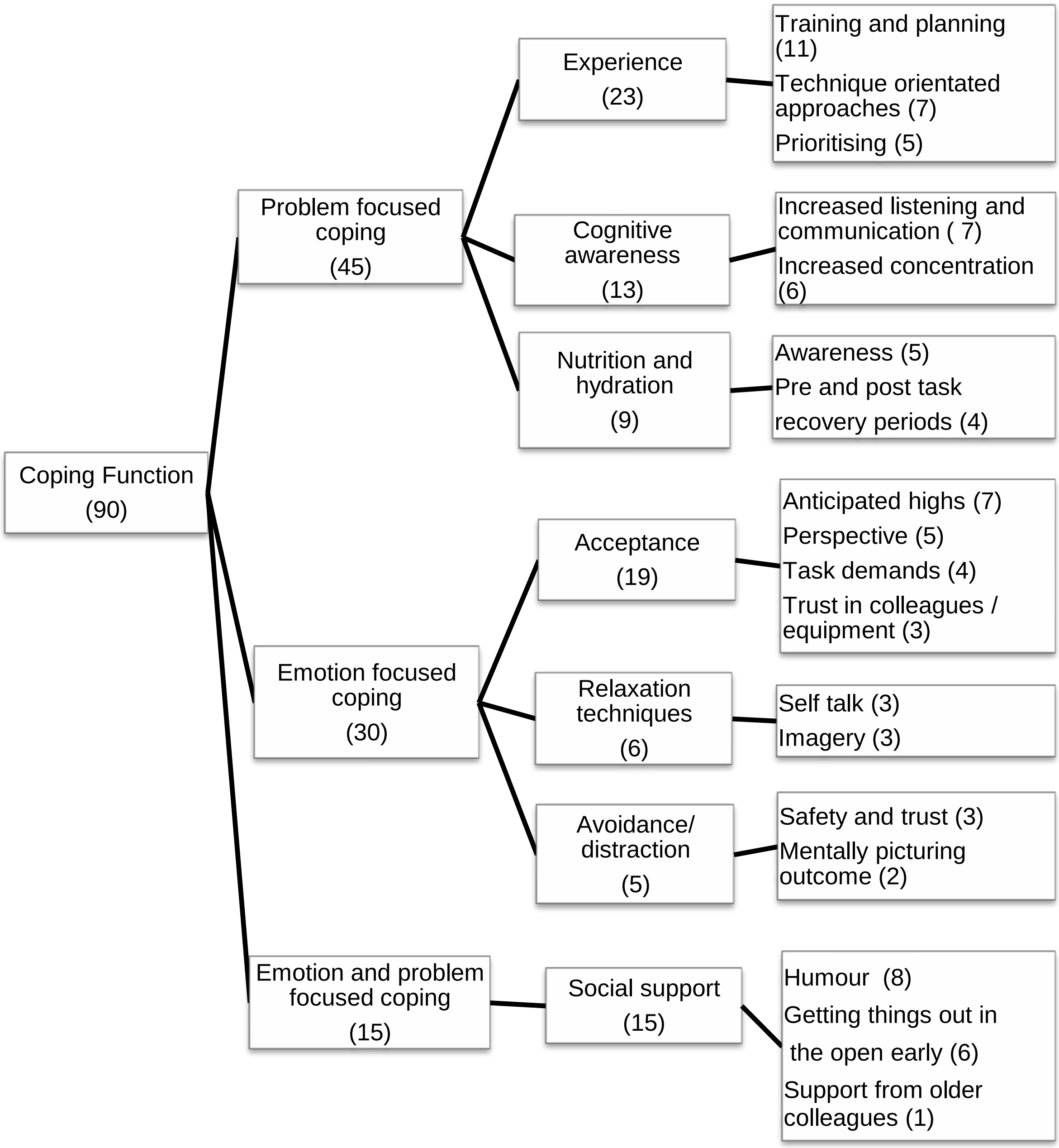

Figure 3.2. Classification of 'problem' and 'emotion' focused coping responses by firefighters during three focus groups

3.3.4 Problem focused coping

Half of all responses from the focus group related to coping strategies that according to Lazarus and Folkman (1984) would be considered to be problem focused. This category was further broken down in to the three themes of experience, cognitive awareness, and nutrition and hydration strategies.

3.3.4.1 Experience

The notion of experience was sub-categorised into three further themes; training and planning, technique orientated approaches, and prioritisation of factors at the incident. During experiences in training environments, personnel reported that they found it to be hard work and representative of real fires, supporting research that suggests that the preparation and management of high task demand is essential during training so that skills are developed for use at real incidents. For example, CM15 talked about the advantages of experiencing the training environment, and applying these skills to incidents:

> *“the training we’ve been put through is the biggest thing...you make some of the best decisions the training environment can put you through, and since you’re going to get good training the experience will come on top of that. In terms of refining skills and techniques it’s invaluable, as the practice makes things second nature and mentally you fall back on your training so I guess it becomes a conditioned reaction”.*

Along with training, experience in planning was cited as the most common way of dealing with anticipated stressors en-route to an incident, and as a way of reducing stress-inducing thoughts. Because there could be a number of minutes sitting on the fire engine until arrival at the incident depending upon factors such as distance to be travelled and traffic, respondents described how they would talk about the potential aspects of the incident, actively gather information, and set up rescue equipment such as SCBA for when they arrive. Often planning begins as soon as they are turned out to the incident from the fire station, as described by FF10:

> *“straight away, before you even get on an appliance, people’s minds are starting to assume roles directly...you’ve already got an idea of what you could or what you should be doing. You talk to each other, who’s doing what, what role you have and what he or she has to do on arrival”.*

During an incident, firefighters reported that they were often at a level where they were at a point of self-perceived near maximal physical and mental exhaustion. The fact that they had been in similar situations before meant that they were able to draw from previous successful performance strategies and focus upon technique orientated approaches, including being able to achieve a level of efficiency or ‘flow’, as demonstrated by a quote from FF9:

> *“no matter how long you have in service the physical demands are the same, but mentally because of your experience you can remain slightly more controlled and focused, there is more a sense of composure. Overeager, rapid respiration and nervous energy are replaced by a methodical approach in the way you go about tasks. I think not about taking shortcuts but about adapting your techniques to ensure the most efficient way of getting through it.”*

There was also the knowledge that they were able to prioritise the needs of the incident with their own capabilities, and multi-task at the scene. CM15 talked about how upon arrival there was a lot that needed to be done despite the physical and mental stressors that existed:

> *"going as one pump (fire engine), you have to know how to multi-task – you have to make entry, put ladders up, put on a BA set, and then go in. All has to be done incredibly quickly. You have to have the physical capability to deal with it and know that your body will mentally take it."*

3.3.4.2 Cognitive awareness

Whilst wearing SCBA, there are often difficulties with vision due to dense smoke or darkness, as well as multiple sources of external noise including the fire appliance pump and engine running, communications over a radio channel, and the sound of the fire, consistent with Kales et al. (2009). To cope with such difficulties, firefighters intentionally gather information and increase communication with others to cover these gaps in knowledge about the incident and to increase concentration on the task at hand.

Participants spoke of their awareness of the cognitive deficiencies that firefighting can cause and the deliberate action taken to increase concentration during the incident. This was seen most often near the point of physical exhaustion, as described by FF4:

> *"I feel myself getting tired and that flicks something inside of me that makes me think 'I need to concentrate on what I'm doing'. My physical performance is going down a bit so I make sure I'm switched on, concentrating hard and thinking 'can I do this next task that I'm being asked?' I'm trying to take in everything that's happening around me, 'what's that smoke doing?', 'what are those flames doing?', and 'what sounds am I hearing?'"*

3.3.4.3 Nutrition and hydration

With the physiological effects of fluid loss during firefighting activities identified in previous research (i.e. Selkirk et al., 1999), it is encouraging that an awareness of nutrition and hydration is used as both a preventative and recovery method against both acute fatigue and the tiredness caused by a 15-hour nightshift. A combination of both nutrition and hydration was often implemented, with hydration in particular an important aspect of pre-task routine as well as a recovery aide post-incident. In terms of incident ground hydration, FF9 explains there is always access to water on the appliances, although there are no set guidelines for when to consume fluids:

“we all have water bottles and make sure we keep them filled up and stored on board (the appliance) because you know when you get turnout out, even it’s for just 15-20 minutes you will sweat buckets. You have really got to stay on top of hydration, because the kit is so heavy you will get thirsty after any type of job but especially if wearing BA…when you are at the incident it really is a case of rehydrate as and when you can, although all the trucks have drinks bottles and fireground feeding packs so can always get fluid.”

For many firefighters, the provision of substantial carbohydrate intake before the shift was seen as an essential part of being able to endure the anticipated physical strains of a nightshift. For example, FF15 states how before work:

“I know I’ve taken in enough food to last me all night should the case arise. At an incident in the middle of the night at 4am, people’s blood sugar levels are naturally low and if you’re facing maximal effort there’s a lot more stress on the body than, say 9am”.

3.3.5 Emotion focused coping

Participants talked about a number of coping responses which could be considered by Lazarus and Folkman (1984) to be emotion focused. The emotion focused strategies were categorised into the broad themes of acceptance of the situation, avoidance of or distraction from the stressor, and utilisation of relaxation techniques.

3.3.5.1 Acceptance

By far the most common emotion-focused coping method (19 of the 30 emotion focused responses) was the use of ‘acceptance’. This encapsulated the ability of the firefighter to accept the situation they were in, the reasons they were there, as well as having trust in colleagues and their PPE and the awareness of anticipated highs that they would expect following the incident. Although no attempts were made to address the cause of the stress, there were examples of an acceptance of the demands of the task taking place immediately before donning breathing apparatus and entering the scene of operations, retrieval of fatalities, and immediately post incident. A point made by FF11 highlights this:

“you know you’ve got a lot of hard work coming, and you know you’ve got to work incredibly hard for that period of time, and you know you will be pretty tired at the end of it. You accept the situation because it’s your job to be there. If we don’t do it, no-one is gonna do it, so whatever the job is you owe it to the public to give it your best shot.”

Another area related to acceptance was of the notion that although it is unpleasant at the time, following the incident firefighters would expect to experience feelings of elation and satisfaction as a result of the amount of hard work they had previously put in at the incident. During fatigue, knowing that there will be a high to follow almost justifies the effort required during the incident. FF30 describes these feeling of elation when back at station:

> *“afterwards, even now, it is a total and utter high that lasts the rest of the shift. If you’ve gone in there and pulled someone out and everything has gone well it is a brilliant high despite how hard you had to work or how nasty it was, you just don’t care. You get back to the station, discuss it and get a pat on the back.”*

Despite the risks involved when dispatched to incidents, the fire and rescue service has a range of policies and procedures to ensure the health and safety of staff. Under periods of high demand firefighters described how the first consideration is safety, achieved through an acceptance trust in their equipment and those around them, as demonstrated by CM15:

> *”my first thought is health and safety, always safety first. It’s a dangerous environment, no doubt about it, and in there you absolutely have to trust your equipment, your training and your crew. You have a duty to yourself and also your other teammates that whatever position you have got yourself in that you can get yourself back out of it again”.*

3.3.5.2 Relaxation strategies

With regards to methods to stay relaxed, six of the responses from the firefighters mentioned a stress-inducing ‘trigger’ that was the most profound when the incident was a house fire with ‘persons reported’ on the print-out sheet and then confirmed en-route over the fire engine radio by the control room. Due to the rapid timescales and requirement to use strategies that could be hidden from other firefighters on the fire engine for fear of social evaluation from others, the two common strategies that were stated were ‘self-talk’ and ‘imagery’. FF4 talked about the reduction of arousal through self-talk, and being able to take his mind off what he may be facing on arrival:

> *“I guess I've got a dialogue going on: ‘just calm yourself down, you just need to do the best you can do’ ...once I've got all my kit on and I'm ready to go that's the point where I start to control my breathing and start calming down and really just running through my head what I’m gonna do. I start to build up this image in my head of what the scene is gonna look like and how I am going to act when I get there”*

3.3.5.3 Avoidance and distraction

On a number of occasions, participants talked about how at the point of physical exhaustion during a fire situation, a focus upon the safety of themselves and those with them became an almost automated response. The emphasis moved from actively dealing with the psychological demands of the SCBA firefighting task to simply refusing to pay attention to the psychological and mood effects in order to alleviate the cognitive demands. This strategy is considered to be a form of avoidance by the participants. FF31 explains a situation where he was at a point of physical fatigue:

> *"I became agitated because my body had passed its physical limits and there was a stress because I'd reached my limit of endurance…and afterwards I got a bit aggressive but I don't know if that's a standard response. There's certain unpredictable things you can't train for and it does cross your mind, and you just try to put it to the back of your mind for as long as possible during these times."*

3.3.6 Emotion and problem focused methods: social support

As previously mentioned, the notion of social support can be considered to be both a problem and emotion focused method of coping as attempts may be made to find information from others about the stressor (problem focused) and seek emotional support from others (emotional focused) (Thoits, 1986). Participants identified the support available at their fire station as a place they could normalise and express feelings that could be seen as inappropriate anywhere else. In particular, support from older and more experienced colleagues was valued.

3.3.6.1 Humour

Participants commented that they were able to receive support and solidarity from other firefighters both en-route and after the incident. Key to these themes was the idea of humour, and getting things out in the open as soon after the incident as possible, as described by FF9:

> *"humour amongst ourselves can make things a lot easier. You can have a laugh with each other and you know it's not taboo and no-one is going to frown upon you because all you are doing is cheering yourself and your mates on the watch up. It helps you deal with the trauma and every time you think about it a little smile comes to your face and it takes away some of the stress."*

3.3.6.2 Getting things out in the open early

The notion of getting things out in the open early and amongst their colleagues is expressed below by FF11 who described how:

> *"you talk about the job afterwards. If something's gone wrong or you've messed up, straight after the incident is a good time to get it rationalised and out in the open. During (the incident) you deal with it in an automatic way, and that's where professionalism kicks in. You deal with it in a way that if you were to think about it, wouldn't be normal. The normality comes later, after the adrenalin has worn off, and that can happen back at station"*

This was described as being conducted back at the fire station in an informal setting. FF14 described how on occasion, firefighters from a number of stations would return to one fire station to allow this debriefing to take place.

3.3.6.3 Support from older and more experienced colleagues

One interesting point that was raised was the 'protection' of newer firefighters from experienced members of the watch from other watches if attending the same incident. FF29 talked about an occasion where he was new to the fire service and would often be the subject of humour from his own watch but these same colleagues became very protective of him at incidents:

> *"in a training environment they would always take the piss out of you, and you were often looked at as not really being able to do anything. Although if you went to a fire with other crews attending your watch would be very protective of you, because how the watch is and how they perform is very important and no-one wants to be seen as having any weak links, and from that point they would always encourage you in front of other watches."*

3.3.7 Career stage stressors and coping

Whilst the purpose of the focus groups was to establish fire service specific stressors and coping strategies, the individual interviews conducted with firefighters aimed to establish different types of stressors and the use of coping strategies that may exist at each of three specific career stages (early, mid and late). This was undertaken by considering the specific type of stressor that elicited the use of these strategies.

When asked about the tasks considered to be the most physically and psychologically demanding, all six participants described firefighting tasks whilst wearing SCBA, in particular if there were known to be persons inside in need of rescue. For example, FF31, the most experienced firefighter taking part in the study and described how it was the frequency and likelihood of house fires that made them the most demanding tasks for him:

> *“oh aye… [the toughest thing] would have to be a real hot fire job, something like a house fire really well going. Things like ship fires are probably harder, but they hardly ever occur and I can’t think of any that I’ve been to for years now. But a house fire persons could happen at any time, and sometimes even happen more than once during a shift.”*

The following section will present responses obtained from individual interviews specific to length of service and encompassing the identification of stressors and management at incidents of high physiological and psychological demand, specifically when wearing SCBA.

3.3.7.1 Early career

FF2 and FF3 were the least experienced firefighters who took part in either the focus groups or individual interviews in this study. Having spent the first four months of their career undertaking a full time development programme at a fire service training school they were now based at operational fire stations and considered to be probationary (or developing) firefighters, a status that encompasses the stage between training school and competent firefighter status.

One of the stressors identified at this career stage was gaining an understanding of personal limits during training exercises. The focus groups demonstrated how confidence gained from successfully performing in live fire becomes a key component of problem focused coping, and it is through being tested in these environments and getting through them early in their career, and in front of the more experienced peers, that this confidence develops. FF3 provides an example of this in his interview:

> *“the more you’re in the job the more you’ll be able to appreciate what you can handle, you know your limits but I am still learning about experiences”*

Control of arousal or finding their optimal arousal level appeared to be difficult, as evidenced by FF3 who talked about his experiences of being in early career and struggling to control arousal during incidents. FF3 described his first few experiences of fires and the rise of his emotions when at the incident:

> *“in my first few fires my excitement levels were right up and I was like a cat on hot bricks…but I soon realised that nobody else at the job seemed to be like this and I don’t think it is particularly helpful to be seen as ‘hyped-up’ but you can’t help it really.”*

At this career stage the greatest stressors were not related to the physiological demands or the threat of performance in novel environments, but instead the need to ‘buffer’ and hide emotions from other firefighters en-route to firefighting and SCBA. In order to manage their emotions, there were examples of the early career firefighter using an emotion-focused coping method, such as positive self-talk. This was demonstrated by FF2 saying how when he receives an emergency to a house fire:

> *“I just try to stay calm, at the incident. You’re in a situation that you’re not used to, it’s a shock to the system and you just have to get a grip of yourself and say ‘stay in control’...the more stressed you get the harder it’s going to be so it’s a case of just coming to terms with the situation and staying in control”*

3.3.7.2 Mid-career

Participants categorised as being in ‘mid-career’ discussed being in a period of refining their firefighting skills. Stressors were not as focused upon the physical demands or arousal control during firefighting activities, as mentioned by the participants in early career, but instead upon the fear of making mistakes during training environments where mistakes are not expected by firefighters at their level of experience. Although the specific environments related to stressor occurrence were found in firefighting and SCBA activities, these stressors were more commonly experienced during training environments. CM 15 highlighted the notion that during training, responses and decisions that should be almost automated and instinctive as a result of successful experiences, were instead becoming more deliberate and over-thought as a result of being observed by training officers, and had to be managed through the use of self-talk:

> *“stress from my point of view comes from the training environment because I always felt you were being observed and looked at to fail. People always highlight when you do things wrong and this stress affects performance. You have to think about how to do it instead of just doing it because you know you’ve had the training, and since it’s not automatic then you are more likely to do it wrong. In these situations I have to consciously think in my head about how to do it by the book, almost providing myself with a running commentary from the training guides.”*

During mid-career, the concept of being at their peak of performance was mentioned, with participants stating how when faced with the high physical requirements at operational incidents, they are able to perform effectively and cope with the demands of the activity. This is due to their increased understanding of efficient movement and search techniques, and a more thorough understanding of their mental capabilities, including recognising when they are starting to suffer a decline in mental acuity. CM14 provided an example of the point when he felt that he was able to meet all the demands of an incredibly hot house fire using the problem-focused method of technique oriented approaches:

> *"physically it was as demanding, but there was less a sense of panic and more a state of composure. That level of discomfort and tolerance became extended, because physically I could go further and mentally deal with that...I could push myself and maintain that sense of mental acuity and control it instead of it controlling me through deliberately focusing upon my technique and movements."*

3.3.7.3 Late career

Both participants at this stage were firefighters in their late 40's and approaching retirement that can be taken at either 30 years' service or when aged 50. They had completed 29 and 31 years of operational service respectively. There were three main types of stressor reported by these participants during incidents involving firefighting and SCBA. This included having to reassess and adjust their physiological limits during the incident, reaching their physical limits quicker than firefighters in early career stages, and becoming frustrated by this. Coping strategies included the firefighters knowing when to move slightly slower to prevent exhaustion, such as seen in mid-career but for a different purpose, and knowing when to ask for help, as described by FF29:

> *"you notice yourself getting irate with yourself because you can't do what you physically want to do because you're that worn out from the incident. Then you get more and more frustrated as you get tired, and the only way to solve this is to slow down a little bit, or ask someone else in the team to assist with carrying some of the kit."*

The coping techniques used by FF29 could be considered problem focused due to the deliberate attempts by the firefighter to implement these actions, whilst asking for help can be categorised as a social support mechanism. Late career firefighters also discussed how they would contribute to the problem focused coping strategies for younger firefighters en-route by assisting with their planning and increased communication, as FF31 describes:

> *"we are a team and I know what the person on that side of the appliance should be doing. If there was a younger firefighter in that place then I would always take the lead and assist them, giving them advice and attempting to calm them down and give them clear instructions."*

3.4 Discussion

3.4.1 Overview

The present study was intended to explore the stressors and coping strategies of firefighters responding to operational incidents, and to identify the stressors that may exist for firefighters operating in a metropolitan and predominantly built up urban environment. It has previously been stated that the ability of personnel to identify acute stressors has the potential to prevent the emotional exhaustion that has been found in emergency workers such as occupation 'wear and tear' factors including work overload, depression, anxiety, and hypertension (Murphy et al., 1998). Negative reactions to occupational stress have been found to cause 'burnout', considered to be brought about by chronic emotional and interpersonal stressors whilst at work that may result in the progressive responsibility of the individual to carry out their job (Freudenberger, 1983). Maslach and Jackson (1981) have identified three major characteristics of burnout, including a progressive increase in feelings of emotional exhaustion at the end of a shift, low energy levels during the workday and an apprehension about facing further exposure to the working day. Following the depletion of their emotional resources, an individual may then create negative or cynical attitudes towards others, alongside de-personalising people and becoming 'emotionally hardened'. Finally, the third characteristic of burnout may see the individual evaluating themselves negatively, leading to a sense of inadequacy and reduced personal accomplishment (Mitani et al., 2006). At present, despite the rapidly growing body of nature of stress and burnout in organisations, Halbesleben et al. (2006) describe how relatively little research has been conducted to develop strategies for reducing burnout, particularly within the contexts of fire departments.

The general agreement amongst participants was that fires in residential, marine and commercial premises are the most demanding task faced by firefighters due to their frequency during a typical shift. Findings are consistent with Mora (2003) who found that in the firefighter fatalities studied, all locations were enclosed structures but varied according to size, height and type of construction, and therefore the broad range of premises reported may be expected to be demanding due to the potential wide range of structures they may attend during a shift. The environments and situations requiring firefighting whilst wearing SCBA were considered by the participants in this study to place a number of physical and psychological demands on the individual including maximal physical exertion, risk of injury to the firefighter and others in the team, and a likelihood of encountering fatally injured persons, consistent with Sommer and Nja (2011). Other incidents mentioned in this study included road traffic collisions, hazardous material incidents, animal rescues, and attending false alarm actuations.

The common occurrence of fire as the greatest and most frequent occupational stressor was consistent with previous physiological research in firefighting (Barr et al., 2010). Findings go against previous trauma studies, such as Baker and Williams (2001) who stated attending an incident involving children was the greatest incident-related stressor, and Bryant and Guthrie (2005) who found 53% of respondents stated motor vehicle accidents to be the most traumatic. However, this may have had more to do with the wording of the questions by the researchers, emphasising ‘traumatic events’ as opposed to the phrase ‘demanding tasks’ used in this study and the subsequent willingness to talk about the psychological demands over the physical by participants. The lead researcher in this study deliberately did not use the word ‘traumatic’ but instead used ‘demanding’ when asking participants to describe incidents and tasks. Similarly, participants in this study were asked to describe how they ‘managed’ the physiological effects instead of ‘coped’. These steps were taken in order to reduce any perceived associations with clinical psychology or medical research.

In terms of responses at career stages, firefighters in early career discussed stressors relating to arousal regulation that could be managed through emotion-focused techniques. Research of career stage coping is comparable to groups in ‘early’ adult athlete stages who have also demonstrated the use of emotion-focused strategies to manage stressors (Thelwell et al., 2007). Mid-career firefighters described fewer stressors as a result of establishing their physiological and psychological capabilities and optimal techniques through experience at operational incidents and training exercises, although observation stress was present when at training school. This observation stress was managed through use of self-talk, although there was deliberate use of problem focused methods at operational incidents where the participants were able to adjust their technique when required, consistent with the behavioural coping strategies reported by middle aged marathon runners (Buman et al., 2008).

Finally, late career stressors were characterised by the frustration of reaching fatigue quicker than when they were younger, and were managed by changing technique but also by asking for assistance. Late career firefighters were also found to provide psychological support to facilitate the coping strategies of early career firefighters. The implications of older firefighters having the skills to assist new firefighters is consistent with previous research by Holland (2008), who suggests that increased years of experience in the emergency services is correlated to psychological health due to the opportunity to learn optimal methods to manage the psychological effects associated with exposure to potentially disturbing incidents.

3.4.2 Problem vs. emotion focused coping

To manage the demands of firefighting tasks involving SCBA, firefighters in this study utilised a number of problem focused approaches more often than emotion focused methods, although it remains open to debate as to which is the most effective or appropriate, or even if this distinction is necessary. Lazarus (2000) suggests that the tendency in coping research to pit problem-focused and emotion-focused areas against each other is misleading and the tendency to separate them is flawed, despite them being conceptually distinguishable. It is suggested that due to the interdependence between the two, both work together to complement each other in the overall coping process. It is unlikely that just the one coping style will even be used independently, and even early research by Lazarus (1983) found that both types were used in 80% of all episodes studied. This finding is further supported by Aldwin and Yancura (2004), who found that in sporting contexts individuals alternate between the two methods when in highly stressful situations.

Whilst fire research into this area is limited, sport research into similar facets of stressors (i.e. recovery, fatigue, and injury) has begun to provide a growth of understanding in this area. There are examples of strategies that were classified as serving a problem focused function being stated more frequently than those considered to be emotion focused in elite athletes (Gaudreau et al., 2001). For example, Nicholls et al.'s studies of stressors and coping in professional rugby players (2006), and golfers (2005), found that despite 24 different stressors occurring, 44% could be accounted for by 'injury', 'physical error', and 'mental error'. To cope with these stressors, the researchers found problem focused coping strategies (including concentration, increased effort and planning) to be used almost five times more than emotion focused coping strategies (relaxation techniques, positive reappraisal and acceptance) and avoidance coping strategies (such as thought blocking / stopping, and pulling out).

The findings of the current study were consistent with previous recommendations that suggest that due to the constant re-occurrence of stressors in novel environments, effective usage should incorporate three or four coping strategies that include at least one problem-focused method, one emotional-focused method and an avoidance strategy as a method of dealing with both controllable and uncontrollable stressors (Nicholls et al., 2006). When a stressor is controllable (i.e. en-route and during the early stages of an incident) firefighters should employ problem focused methods, as a strategy designed to influence or alleviate the stressor would be most effective, whilst in uncontrollable situations (such as post incident, or when dealing with fatalities) an emotion focused strategy would be of most benefit since attempts to change the stressor are unlikely to be helpful. For example, in the focus groups and interviews in this study, participants would often talk about the way they managed the demands of a fire, and would typically utilise a problem focused technique early into the incident, and then later on in the incident they would use an emotion focused technique, followed by social support when back on station. Given the potential in firefighting environments to use both problem and emotion focused coping, it would be unwise to advocate one method, and the findings of this study support the frequent use of problem focused, emotion focused, and social support as coping methods.

There are also examples in the literature of emotion-focused techniques buffering later distress in firefighters. Northern Irish firefighters working during military conflict showed that periods of distress were linked to less task focused coping, less emotion focused coping and greater avoidance (Brown, Mulhern & Joseph, 2002). Folkman (1991, 1992) suggests that there are also some causes of stress that are so powerful that an individual may not be able to change the outcome in that situation. Emotion focused coping would therefore be considered more appropriate in instances where there is very little that can be done to change the encounter (Folkman, 1991).

3.4.3 Social support

It was interesting to observe that firefighters were willing to talk about their experiences, sharing information back at the fire station after attending an incident. Firefighters are described by Sommer and Nja (2011) as always working together in teams during operational responses which enables them to interact with and learn from each other, in particular within their own duty watches. Sommer and Nja (2011) have identified that after incidents, it should be commonplace to discuss the performance, and to identify the factors or actions that worked well, and what could be improved at future incidents of a similar nature. These discussions could take place at the scene, on the way back in the fire appliance, or at the station.

Marmar et al. (1996) state that whilst the public expect toughness from firefighters, this often leads to the concept of 'feigned toughness' by emergency responders during the incident. Delsohn (1996) further describes this idea by stating that when firefighters attend an emergency, everybody in the crew likes to be seen and act as a tough guy in front of the public and their other colleagues. Whilst this 'masking' by firefighters at the time of trauma may help protect them from a full conscious appreciation of terror, helplessness, and grief in the short-term, it may result in long term difficulties in integration and mastery of the event (e.g. Carlisle, 1999). By utilising available peer support, feelings experienced during an incident could be normalised and openly discussed and may reduce the likelihood of future difficulties occurring. Fire stations (or in the research of Sommer and Nja, (2011), the inner / restricted cordon of a scene or fire engine) were identified as private environments that could be used as a place for emotions such as fear, disgust and stress that need to be 'buffered' and managed in front of the public during incidents to be openly addressed. These private environments also allow firefighters to receive support and solidarity from colleagues when disclosing information or feelings (Yarnal et al., 2004). Thurnell-Read and Parker (2008) suggest that the group of firefighters that they were researching were all found to display group unity and solidarity that was based upon on the interdependence of all members of the watch on one another when attending operational incidents. Hardships, and the sense of unity involved with having faced the same ordeal were found to build this cohesion, and can be considered an essential part of a firefighting effort. The researchers state how this adversity creates cohesion, which in turn improves job performance. The ability to show consideration for others in the team has also been found to lead to firefighters becoming more attached to the group (Zaccaro et al., 1995) and drawing the group together and closer to the attainment of group goals.

In the absence of a quantifiable level of support required to manage stressors, researchers have described how even the perception of support from colleagues could be utilised as a predictor of coping in firefighters, and it is recommended that a firefighter should know that if they wanted to talk or discuss an incident this could be facilitated on the fire station (Barrera, 1986). Perceived social support has been found to have a significant buffering effect upon 'spillover' to their home life, levels of job dissatisfaction, job stress, and health outcomes in firefighters (Murphy et al., 1999), as well as alleviating acute and chronic stress, and reducing burnout as a result of exposure to occupational stressors in both urban and countryside firefighters (Mitani et al., 2006).

The use of open discussion at the fire station was also found to include humour that may be considered by the firefighters to be inappropriate in other locations, and is consistent with other firefighter research that has found humour to be present on fire stations (Miller, 1995). This humour will often include details or information about the incident that has recently been attended, and is considered to result in an increased bond or a sense of closeness between the firefighters (Fullerton et al., 1992), as well as potentially desensitising the firefighter from the trauma that had recently been witnessed (Miller, 1995).

Other studies, such as the meta-analytic review of front line emergency workers by Prati and Pietrantoni (2010) examined the role of both received and perceived social support, and describe social support as being both positive and negative. The researchers suggested that social support examples from other occupations can be either adaptive by reinforcing or replacing resources that have been lacking; or maladaptive by creating a 'pressure cooker effect' attributed to talking about the event and leading to an over-exposure of serious aspects of the incident. However, the overall conclusion from Prati and Pietrantoni (2010) was that social support is positively related to mental health in first responders, and is a valuable tool in building resilience after demanding emergency incidents. In this study there were no responses identifying social support as a maladaptive coping strategy.

Not all research suggests that social support is useful or even present. The findings of this study are in contrast to previous firefighter research, such as Milen (2007) who found social support is a 'lost' and underused coping strategy in the fire station, due to stress, negativity and an unwillingness of US firefighters to speak about incidents occurring at work. It is unknown why there were differences found in the current study and that of Milen (2007), although further investigation is warranted to examine potential cultural differences between attitudes to seeking support between UK and US firefighters. Similarly, Regehr et al. (2003) in another North American study, found social support, including overall social support and reported levels of support from their family and employer was significantly lower in experienced Canadian firefighters compared to new recruits. The researchers state that the nature of the job, and the different formulations of shift work that exist from fire service to fire service may undermine the ability of firefighters to maintain strong social support outside of the workplace.

3.4.4 Recommendations

A number of coping strategies identified by participants in this study were described as being experienced and developed in fire service specific training environments. This is often achieved by the firefighters reaching their physical and psychological limits during tasks that are either hotter or more complex than anything they are likely to encounter at real-life incidents, and leads to the development of coping strategies during these environments.

Previous studies, such as Graveling et al. (2001), advocate that whilst exposure to elevated temperatures in the training environment is a necessary part of training and should represent realistic conditions to those likely to be faced at incidents, this environment should not involve risks that outweigh the benefits gained, in particular the risk of injury to firefighters caused by fatigue or extreme heat. Although there is the high risk of physiological strain to personnel, instructors and safety officers to consider, it is recommended that firefighters be given the opportunity to use the extremity of the training environment in order to establish what this strain will feel like and to gain the confidence and control from overcoming these demands in a controlled environment. Therefore the benefits of this environment comparable to the risk of undertaking such training exercises requires a balancing act by training officers to ensure that sufficient stressors are encountered by firefighters to enable their coping skills to develop without a likelihood of injury.

Despite advances in the measurement and reporting of physiological effects of SCBA wearing in live fire, to date there is still further research required to understand the psychological deficiencies or heightened responses that occur during SCBA tasks. However, it is recommended that firefighters should be allowed to push themselves to the limit in training and even to exhaustion prior to the task being completed, without fear of reprimand for doing so, in order to establish these boundaries and develop coping methods for consistent performance at real incidents. This environment should also be utilised by the firefighter to identify their optimal levels of hydration and nutritional input, and such techniques to be monitored by training officers to identify any performance degradations that occur as a result of ineffective methods of fluid or carbohydrate replacement.

Through an increased understanding of the factors considered demanding in firefighters and how they potentially cope with these demands, emergency service researchers such as Regehr et al. (2003) have recommended that education about incident stress and self-care must begin in initial training to ensure individuals develop strategies for coping with stress and that these educational programmes continue throughout an individual's career. In particular, this could be further developed to include instruction on how firefighters can effectively utilise self-talk and imagery strategies that have been identified in this study as being important methods of arousal control and technique prompt.

The outcome of training and intervention strategies to firefighters may provide 'psychological protection' (Shubert et al., 2008) when making mistakes and encountering stressors in their early career, but also assist firefighters (such as those in mid-career) who may be experiencing a different set of stressors. In athletes, Tamminen and Holt (2010) suggest that rather than there being a set of effective coping strategies which can be prescribed to deploy in given situations, practitioners should instead consider teaching athletes about how to plan and evaluate their coping by encouraging athletes to reflect upon their coping strategies. The outcome of this approach is that firefighters should then begin to understand when and under what circumstances certain strategies are likely to be effective or ineffective at each stage of their career

3.4.5 Methodological Issues

This was one the first studies to consider the stressors and coping strategies of UK firefighters (at different career stages) during firefighting and SCBA tasks, and the first to apply sport psychology research and theoretical frameworks to the work undertaken by firefighters. As a result, there were a number of methodological considerations that must be taken into account if further research is to be conducted in this area.

3.4.5.1 Coping effectiveness

The results of this study should be viewed with some caution due to some of the methodological difficulties encountered when running the study. There was difficulty in measuring the effectiveness of coping strategies in this study, as the only real measure available was the participants' description of the usage of a particular method or style. Described by Beaton et al. (1999) as the 'healthy worker' effect, the researchers state that length of service itself is a useful way of measuring coping effectiveness as any firefighters who have failed to find or utilise effective coping mechanisms would have left the fire service. A further investigation and comparative study of the coping methods of firefighters who have left the service early or suffered post traumatic symptoms may help establish if these methods are effective as both a short and long term strategy. However, it is stated that due to the complexity of the relationship between psychological distress, the attendance at traumatic events, length of firefighter service, and occupational stress, it would be unwise to establish a simple causal relationship between psychological distress in firefighters and attending traumatic events while on firefighting duty (Dean et al., 2003).

3.4.5.2 Length of service

The fact that participants were classified according to years of service may have also created methodological issues. It could be predicted that that the coping strategies used by firefighters with the longest years of duty are possibly the most beneficial as these methods should have been used and refined during incidents, although at present there is no general consensus that years of active service are beneficial or damaging. Researchers such as Corneil (1995) argue that continuous and repeated exposure to traumatic incidents is a risk factor for PTSD, whilst others suggest that the experience of training and performing within these environments allows for the development of more effective cognitive and behavioural coping strategies (Hytten & Hasle, 1989), thus validating the effectiveness of the more experienced participants' coping methods described in this study as a way of buffering any potential PTSD symptomology.

Beaton et al. (1999), when looking at the relationship between exposure to duty related stressors and post traumatic symptomology, describes the need to 'weight' the different tasks of personnel at the same incident, as those attending may not have had the opportunity to experience the levels of intensity experienced by their colleagues due to task allocation by the officer in charge. It is also why caution is needed when selecting length of service as an indicator of experience of incidents, since the actual amount of exposure is more dependent upon station location. As such two different firefighters with the same years of service based at two different fire stations (or even the same station) could have two very different levels of exposure, yet this differentiation in amount of exposure was not considered in this study.

It is possible that there was also an element of socially-desirable responses in the focus groups, in particular amongst younger firefighters in the presence of more experienced colleagues and peer leaders within the watch. As a result, there exists the possibility that the stressors identified during the focus groups may simply represent the stressors experienced by personnel with more than 10 years' service, with younger firefighters following this lead. However, these effects were designed to be minimised due to the use of individual interviews with firefighters who had not previously taken part in the focus groups. Findings from the individual interviews identified the presence of firefighting and SCBA activities as the most demanding across the career stages, which suggests that the potential for socially desirable responding may have been managed through these interviews.

3.4.5.3 Goals and values

There are methodological difficulties in conceptualising what can be considered to be a 'successful' method of coping and it is difficult to establish if the coping strategies identified in this study improved firefighter performance. Firefighting tasks are often multi-faceted and, unlike in sport, individual improvements are hard to measure or quantify due to the number of factors outside of the firefighter's control. The overall judgment of whether the situation or stressor was successfully resolved is based upon an individual's values and goals, as well as their expectations concerning various aspects of the encounter. For example, during this study, one participant identified that there may not have been a resolution of the stressor but they evaluated the outcome favourably if they considered the demands of the stressor were managed as well as they were able to with the resources that were available at that time.

Alternatively, although the situation may have been resolved successfully, the individual may still see the outcome as unsatisfactory if the solution was inconsistent with their values and goals, as well as what they thought they could achieve with the resources they had available at the time. In a fire situation this represents a key concept, due to the factors that are outside of the individual's control that may contribute significantly to the final outcome of the incident.

3.4.5.4 Lifespan coping

The measurement of lifespan coping in firefighters, whereby the individual reorganises their coping skills to produce further unique coping actions to serve a specific coping function (Skinner & Zimmer-Gembeck, 2007), were considered at each of three career stages. In the absence of any published firefighter research, comparable examples were identified in sport psychology studies, although this cannot be considered to be a directly transferable knowledge framework.

One of the problems in applying athlete lifespan coping to firefighter populations is that age is rarely an indicator of experience, despite athlete coping categorising individuals by their age. For example, at the present, earliest point of entry in the UK fire service is 18 years of age although there are no upper age limits imposed upon firefighter applicants. Therefore if two firefighters aged 40 are studied, it is possible that one firefighter may have 22 years operational service, and the other may have one year of duty (with both firefighters potentially using differing coping strategies), yet they would often be grouped together by age in the athlete methodologies are applied. In addition, in athlete studies that have considered coping in older adolescence (between the ages of 18-22), the tendency of research has been to focus upon university / student athletes (i.e. Kim & Duda, 2003), with this dual balance of academic studies and physical / sporting performance rarely found in the fire service.

3.4.6 Further Research

Further research is required to establish if the coping strategies described in this study are effective or maladaptive in the long-term. Lazarus and Folkman (1984) suggested that immediate effects of a particular coping strategy can be measured using changes in mood if it helped the individual solve or reduce their problems, or did not change that stressful situation at that moment in time. It is important to examine if the coping strategies identified in this study are useful in the long-term or throughout the whole of the firefighters career. Future research is recommended to examine the long term indices of psychological and physical well-being, and general satisfaction with the particular activity or situation in firefighters, with these states considered to be reflective of successful adaptation to the environment (Hanin, 2000).

Ntoumanis and Biddle (1998) looked at coping effectiveness associated with athletes general emotions (considered a predictor of long-term effectiveness of coping strategy use) and found that the coping strategies that predicted positive affect included suppression of the competitive activity, seeking social support, and effort related coping strategies. Predictors of negative behaviours, however, included behavioural disengagement, venting of emotions and seeking social support. This study did not consider long-term effectiveness, although future research is recommended to establish methodology or adaptation of previous research that may make this feasible.

Finally, when attempting to research lifespan coping, sport psychology researchers have identified that further research is required to identify the coping strategies of athletes, by selecting participants based upon specific criteria (such as years of experience) and then following individuals longitudinally across a career span. At present, the lack of a theoretical framework to guide research efforts is impacting upon the knowledge of researchers to understand how coping develops (Horn, 2004). Furthermore, specific studies examining the specific career span coping of firefighters are recommended to further knowledge of the organisation, differentiation, selection, and flexibility of coping responses used to deal with the stressors that will exist throughout their operational career.

3.5 Conclusions

The current study considered the demands of firefighting in firefighters and found that most stressors reported by firefighters and crew managers could be related to the physical demands of fires and SCBA use, leading to physical fatigue, heat stress and dehydration, and post fire fatigue. In addition, the participants reported that there is a requirement to adapt to the physical demands of firefighting environments rapidly. Other reported stressors included risk of injury to themselves or colleagues, psychological demands of the firefighting activity (such as incorrect decisions, frustration, and sleep deprivation), stressors associated with fire appliance driving, and dealing with fatally injured persons at the scene of operations.

The findings of the current study would suggest that to facilitate coping, when firefighters are en-route to an incident they should be given as much information as possible and roles should be clearly defined as soon as practicable. During the incident the importance of nutrition and hydration should be understood and facilities made available to firefighters to take on appropriate nutrition and maintain hydration levels at the incident. During the task experienced firefighters should be paired with less experienced firefighters to allow the latter to safely gauge and make informed decisions about the effects conditions are likely to have upon their physical and mental performance. To achieve high levels of performance operationally, it would appear beneficial that in training situations the preparation and management of high task demands identical to those likely to be encountered operationally are considered, and firefighters are allowed to create and fine-tune necessary coping strategies to deal with the wider environment, including training in the correct use of self-talk and imagery techniques. Finally, post incident, it is essential that firefighters are given the opportunity to talk openly about the incident at the fire station. This may include humour considered inappropriate outside of this environment; and must allow firefighters the opportunity to able to critique and obtain feedback on factors of their performance without fear of reprimand from officers.

There were found to be different stressors at different career stages, ranging from the control of arousal and unknown limits of physical and mental endurance in fire environments in early career, to fear of mistakes and judgment in training environments mid-career, and having to deal with degradations in physical capability in late career. The findings of this study are consistent with the Lazarus and Folkman model (1984) and offer potential theoretical and applied implications for serving firefighters, fire service training officers, and well-being advisors for the development of stress management solutions to the stressors involved with firefighting incidents. The findings are in keeping with the recommendations of Holland (2008) who advocated the establishment of psychological health standards for emergency service personnel and the creation of educational seminars that offer practical strategies in the implementation of optimal coping methods and the avoidance of detrimental coping methods.

Chapter 4

A longitudinal study of the breathing apparatus demands and coping strategies of firefighters in early career

"Part of the attitude problem is the notion that you cannot be an aggressive firefighter and practice safety. When we start off as firefighters, we strive to gain the respect of our peers by being known as being 'aggressive' at incidents."

Endle, (2003, p.3)

Chapter 4 - A longitudinal study of the breathing apparatus demands and coping strategies of firefighters in early career

4.1 Introduction

Following the identification in chapter three that incidents involving SCBA were the most demanding both due to the physical workload required to complete the task and the psychological facets that may be affected, this chapter considers how these skills develop in early career. It is also essential that such skills do develop quickly due to the high risk environments newly qualified firefighters may be required to respond to. For example, in July 2004 two wholetime London firefighters died after responding to a fire at a three storey shop and dwelling on Bethnal Green Road in London. A team of firefighters rescued two people from the roof whilst others were sent to the basement to ventilate the fire, and this is the location where the two firefighters were killed, one of whom had just qualified from training school two months earlier. An investigation later carried out by the Fire Brigades Union (FBU) identified a number of key issues, with their 2008 report into firefighter deaths describing the issue of SCBA wearing in early career. The report states:

> *"it has become brigade policy to commit inexperienced firefighters into incidents in breathing apparatus whilst in their probation. There has never been consultation on this matter, nor has it been possible to discover when or why the brigade policy was changed"* (p.33).

This report also identified the fact that crews were working to the point of exhaustion when this condition should have been recognised by themselves and the officers at the scene. The report cites findings by Hill (2005) stating that 'several BA wearers came out of the premises exhausted and with fire gear steaming'. In the aftermath it was recommended that of the 68 recommendations made by the FBU, all personnel should undergo training which involves experiencing heat stress and being able to observe its effects on themselves and others.

Yet almost eight years on from the events that occurred that day, it is still often policy for probationary (recently qualified) firefighters in the UK to wear breathing apparatus whilst in their probationary period. Whilst there are a number of protocols put in place by different UK FRS's to identify unqualified (i.e. via a black square worn on the helmet) or qualified without experience (i.e. denoted through red triangles worn on the firefighters helmet) on the fireground, a breathing apparatus wearer with red triangles is expected to conduct exactly the same duties as the other more experienced firefighters. At present there are very few control measures available with the exception of the officer in charge pairing inexperienced wearers with experienced personnel. As such, the SCBA skills developed during firefighters' initial experiences in training exercises undertaken in both ambient and live fire conditions must be sufficient to ensure the probationary firefighter is able to perform effectively at real life incidents, since both environments represent an invaluable contribution towards competence.

The exact skills required by firefighters to perform effectively when attending tasks that involve firefighting and the use of SCBA are still open to debate. Exploration by researchers such as Nevola (2003) has identified that the core competencies that lead to an effective firefighter include maintaining high levels of mental and cognitive function during firefighting tasks, the ability to work effectively as part of a team, clear communication skills, and the ability to make the correct decision at short notice while exposed to extreme levels of stress. However, little is known about how these skills for firefighting and SCBA activities develop. To date, there is a lack of research that has attempted to identify and examine the specific tasks, levels of perceived control, and coping strategies used by recruit and probationary firefighters during firefighting tasks involving SCBA. Furthermore, there has been no longitudinal examination of these factors to identify how they may change during their career development as a firefighter.

4.1.1 Emergency services stress

Stress is more likely to be involved in the helping professions (including emergency services) than any other occupations due to stress-provoking conditions associated with the work, responsibility for other people's lives, unpleasant encounters with people, and the gap between aspiration and achievement (Stinchcomb, 2004). Firefighters also fall into a category of 'helping' professions, with a combination of high demand / low control environments producing an occupation that creates a high strain on the individual (Karasek et al., 1988) due to a range of acute stressors. Researchers such as Beaton et al. (1998) have identified the five components of on duty firefighter stressors as being catastrophic injury to self or co-worker, gruesome victim incidents, rendering aid to seriously injured, vulnerable victims, minor injury to self, and exposure to death and dying. Similar incident-based stressors have also been reported by Baker and Williams (2001) and include firefighters' concerns about safety of oneself and colleagues, handling dead bodies, and attending a chemical incident.

Henderson (2010) has identified that there is consistency within stress literature supporting the idea that stress and time pressures can lead to a multitude of cognitive decrements, including increased errors, neglect of peripheral cues, reduced working memory capacity, and speed / accuracy trade-offs. It is thought that these stress effects are mitigated in the fire service through the deep and extensive organizational knowledge based that must be acquired to serve as a firefighter. Owing to the knowledge and experience obtained, task demands are reduced, and there is the additional benefit of greater confidence in an individual's ability to perform under demanding conditions induced by reducing the threat of stress. Given that the trainee firefighter at training school must master and pass a multitude of subjects including emergency medical treatment, the chemistry and physics of fire, building construction and structural collapse, understanding of hazardous materials, and fire suppression techniques, the knowledge breadth required is extensive.

Experienced firefighters, including those who took part in this research, have demonstrated the ability to identify and deal with a wide range of stressors that may be likely to arise at an incident using a broad depth of knowledge, as detailed in chapter three. In one of the few firefighter studies utilising a longitudinal methodology, Murphy et al. (1999) assessed 188 urban US firefighters with an average length of service of around ten years, and explored occupational stressors experienced in the past 10 shifts, before re-visiting the participants two years later. Of the 19 occupational stressors identified during the baseline collection, only five stressors changed significantly over time and only three stressors showed an increase. With the firefighters demonstrating elevated and stable levels of stress symptomatology over the two year period, this suggests that fire service stressors may be present and be robust to any changes over time. Therefore, the development of research identifying suitable coping strategies at an early stage into a firefighter's career has potential benefits to the individual and the fire and rescue service due to the likely presence and persistence of stressors during operational duty.

Newly recruited firefighters represent a unique study population and an interesting study sample for stress and coping research as, in their typical duties, they are exposed to the same high frequency of acute physical and psychological stressors as experienced colleagues, but without prior experience and practice. Despite this lack of experience, this population has previously demonstrated robustness and resistance to work based stressors from an early stage. For example, in a study by Regehr et al. (2003) involving firefighters in the Greater Toronto area assessing 65 newly recruited firefighters during training, results found that there was no difference in traumatic stress symptoms in trainee firefighters between weeks one and ten.

Further research examining appraisals in trainee firefighters to stressors by Bryant and Guthrie (2005) suggest that it is the individual's appraisal of a traumatic event and their capacity to respond to the experience that plays a crucial role in being able to adapt successfully. By studying trainee firefighters at training school and after trauma exposure 6 months after commencing duties on station, the researchers found that although no personnel met the criteria for post-traumatic stress disorder (PTSD) at either stage of the study, all of the participants had been exposed to at least one traumatic event in their career. However, the limited extent to which firefighters displayed maladaptive processes suggested that the way firefighters make interpretations about themselves and their role in the traumatic incident and its aftermath is important in how they adapt to the experience. The researchers state that firefighters' stress reactions may be associated more with concerns about self-image than with concerns about other issues, characterised by high levels of perceived competence and self-efficacy. What is less known is the specific stressors faced by trainee and early career firefighters, in particular when transitioning from the training school environment to the operational fire station, and the duration of the coping strategies that may exist.

4.1.2 Coping

The central themes of coping styles and trends have been discussed previously in this thesis, with research and literature representing a case for the application of the transactional model (Lazarus & Folkman, 1984) to the context of firefighting. This model is characterised by the problem focused and emotion focused paradigms of coping utilised by the individual to consciously and deliberately execute efforts to manage appraisal demands that exceed their resources (Folkman et al., 1986; Lazarus, 1999). To establish this appraisal demand an individual will perceive the demands and estimate how they will perform as a result, and then seek to evaluate how they subsequently performed. The latter, whereby an individual is able to accurately assess their own abilities in response to identified stressors, is considered to be central to the functioning of those working within the public health and safety professions (Eva & Regehr, 2005) despite the 'relatively poor' ability of most people to self-appraise (Regehr et al., 2009).

The optimal coping strategies of firefighters in their early careers are yet to be fully understood. It is suggested by Dowdall-Thomae (2009) that in order to meet the stressor demands, newly appointed firefighters may be better suited to seeking social support and focusing upon problem focused strategies which should assist with the awareness of outcome coping efficacy, which in turn will assist with stress management and mental preparedness. However others, such as Baker and Berenbaum (2007) state that the emotional approaches to coping such as 'blaming self', 'wishful thinking', and 'avoidance' can also contribute to decision making through the exploration of problem solving. It is likely that the recommendations of both researchers have a place in the coping strategies chosen by firefighters, as demonstrated in greater detail within chapter three with experienced personnel.

4.1.3 Perceived stress and mental toughness

It is suggested that athletes who are able to cope with stressors possess high levels of 'mental toughness' that may also be applicable to firefighters (Dowdall-Thomae et al., 2008), leading to optimal levels of performance in the stressor environment that can lead to more effective rescue efforts. Kaisler et al. (2009) found that greater mental toughness was associated with increased use of problem focused strategies (including seeking information, social support, planning and increasing effort) but less use of emotion focused and avoidance strategies.

In an attempt to conceptualise mental toughness, Jones et al. (2002) suggest that mental toughness is the natural or developed psychological 'edge' that enables an individual to cope better and be more consistent and successful in remaining determined, focused, confident, and in control under pressure. A further important aspect of the dimension is that mental toughness should consistently lead to the achievement of success. The researchers also describe how mental toughness is about the individual knowing what their priorities are at any given time, and requires them to possess high levels of ability for controlling motivation, focus / attention, confidence, and stress. Individuals should also be able to maintain technique and effort whilst experiencing both physical (i.e. fatigue) and emotional pain to be considered as being ‘mentally tough’. These factors are also similar to those skills considered to be present in an effective firefighter (Nevola, 2003), and it can be argued that the facets defined by Jones et al (2002) may also be relevant to a firefighting SCBA environment.

It has been previously suggested that people who join the emergency services professions may already have ‘mental toughness’ or a pre-existing and unique set of characteristics that enable them to successfully confront and manage the intense stressors of their job (Salters-Pedneault et al., 2010). It is important to explore whether there are a set of traits that exist in trainee firefighters that become a stable response disposition influenced by the training environment, an acquired response associated with their training, or a later response once the skills acquired during training are utilised during operational responses to incidents.

4.1.4 Perceived control

Related to the coping of individuals and levels of perceived stress is the degree of control the individual perceives themselves to have over the stressor-inducing task. Previous researchers such as Stinchcomb (2004), describe how perceived stress increases when an individual is not able to avoid, alter, or control environmental demands placed upon them, such as highly demanding situations outside their perceived sphere of control. As a result, the less control the individual has over what they are expected to do and the outcome of their actions, the more stress they are likely to experience. Furthermore, stress can be directly linked to lack of control since it is only what the individual perceives they are not able to control that has the capacity to create stress for the individual.

The notion of perceived control within a particular environment has been studied extensively in psychology in a variety of forms, due in part to its association with a variety of cognitive, affective, behavioural, and physiological outcomes (Ng et al., 2006), although perceived control has yet to be explored specifically in firefighters. In general, personnel who consider themselves to have a greater control over their external environment are typically confident, alert and directive in trying to control their external environments (Rotter, 1966). They have also been found to possess higher levels of job motivation, successful job performance, job satisfaction and leadership than those who regard themselves in more of a ‘passive’ role within their environment (Spector, 1982). It has been suggested that this perception of control has psychological benefits for well-being, even without the actual occurrence of control (Miller, 1980). Studies have demonstrated that the possession of a stronger need for self-determination and competence by individuals can lead to a source of psychological ‘empowerment’ over work activities, whereby the individual will then perceive a high-likelihood of obtaining their desirable outcomes as a result of the effort they put into the task (Ng et al., 2006). In contrast, a lack of control has been found to be associated with experiences of greater stress in individuals within occupational settings (Langer, 1983), with these individuals holding the perceptions that any of their behaviours are unlikely to achieve a desired effect from the effort they put in. Within extreme sport environments, Weston (2012) describes that in extreme environments, the high number of eventualities that the individual has no control over may only lead to heightened anxiety and more negative emotional responses from the individual.

Within the context of firefighting, it has been suggested that coping may mediate the individual’s locus of control, whereby internal locus of control is associated with the use of problem focused activity in both high and low exposure groups (Solomon, 1988). Others, such as Brown at al. (2002) describe perceived levels of control as having a strong relationship with psychological distress to individuals exposed to traumatic stress events in Northern Irish firefighters, although locus of control is only able to predict psychological distress under less traumatic situations. In situations attended by firefighters that are considered to be highly traumatic, it is incident-related emotions (more than locus of control) that predicts psychological distress. Personnel with an external locus of control are more likely to be engaged in the form of avoidance coping (and thus higher levels of psychological distress) than task or emotion focused methods (Brown at al., 2002).

4.1.5 Aims of chapter 4

Firefighters are exposed to high levels of traumatic stress from commencement as a trainee firefighter and these levels have the potential to exist for the full duration of their career. Previous research has found that inexperienced firefighters will report high levels of traumatic stress despite relatively short periods of exposure (Regehr et al., 2003). However, several issues remain unclear: first, what are the most demanding tasks of early career? Second, what are the specific aspects that make the task so demanding? Finally, how do firefighters cope with such demands?

Although personnel will encounter a wide range of incidents, including road traffic collisions, accidents involving hazardous materials, fires, and a multitude of other duties, the focus of the current study is to assess firefighting tasks and those requiring the use of SCBA. At present the numbers of injuries and deaths whilst wearing SCBA (at least 13 of the 22 UK firefighter deaths since 2003 according to the FBU, 2008), along with the likelihood and frequency of wearing SCBA (as identified in chapter 3), provide a rationale for the further study of these occupational tasks. Therefore there are three aims to chapter 4

i. Identify the stressors and coping strategies that are recurrent, and any changes that occur over the first 12 months of operational service.
ii. Consider the individual's perceived control of the stressor, perceived effectiveness and performance on the task following coping taking place.
iii. Examine perceived changes and similarities in task demand and complexity from training school training scenarios to on-station emergency call-outs.

4.2 Method

4.2.1 Participants

A newly appointed fire and rescue service recruit course were recruited to take part in this study (n = 14). Eleven were male and three were female, with a mean age of 27 years (ranging from 18 to 36 years). At the beginning of the study, all were trainee firefighters (referred from here onward as simply 'firefighters') on the ninth week of a 13-week initial firefighting course that acts as a compulsory starting point for all career firefighters. None of the firefighters had any previous experience of wearing SCBA through previous employment.

Since the study was run over a 12 month period, participants were based full-time at the non-residential fire service training school in months one and two. From month three onwards, all participants had successfully passed their initial firefighter training, and were now considered probationary firefighters and based on one of 17 full-time fire stations. Probationary firefighters perform exactly the same tasks at operational incidents and work the same duty shift system as experienced firefighters, and are considered to be at this stage until the completion of a three year development programme. In addition, participants were posted to the same duty watch on the same station for the duration of their probation period.

All participants were given a participant number that was randomly allocated to them at training school by the researcher with the prefix ‘FF’ followed by their allocated number (for example FF2). Unlike in chapter 3, this number did not provide any additional information about the participant. There were no exclusion criteria for any parts of this study and all participants who took part in this study remained in the fire service during the duration of data collection.

4.2.2 Materials

4.2.2.1 Participant Information booklet

This participant booklet formed the only method of data collection for this study and consisted of three sections: (a) task information, stressor checklist and open ended stressor boxes to elaborate on the answers; (b) subjective performance measures; (c) Ways of Coping Questionnaire (WOC) (Folkman and Lazarus, 1985). A blank copy of this participant booklet is provided in appendix D.

(a) Task information

There was space for participants to describe the most stressful and demanding SCBA task they had faced in the previous month. Due to the potential range of tasks faced by firefighters this section was left open-ended and unstructured, with participants describing any single activity that required the use of SCBA.

The next section contained three pre-populated bullet points asking participants to list the three factors that made the task they had described so demanding. Participants were then required to provide further information as to the context this task was conducted by ticking relevant boxes. Contexts included: live fire conditions, ambient conditions, training environment, real life incident, search and rescue, firefighting, guidelines, and gas tight suit used.

(b) Subjective Performance Measures

In order to assess the level of control; coping style effectiveness; satisfaction with performance; and task severity, a number of 100mm visual analogue scales were utilised. Together these were grouped as ‘subjective performance measures’. Items were worded as follows:

- Control: ‘Please indicate how much overall control you considered yourself to have over this task’
- Coping effectiveness: ‘Please indicate how effectively you considered yourself to have dealt with the demands of the task, and how effective any coping methods were’
- Performance: ‘How satisfied were you with your overall performance on this task?’
- Previous experience: ‘How would you rate this specific experience in terms of previous breathing apparatus tasks?’

These scales were anchored from 0 (‘no control / ineffective / unsatisfied / easy’) to 100 (‘complete control / very effective / very satisfied / most severe task undertaken’)

(c) Ways of Coping Questionnaire

The Ways of Coping Questionnaire (WOC) (Folkman & Lazarus, 1985) is a 66-item questionnaire containing a wide range of thoughts and acts that people use to deal with the internal and/or external demands of stressful encounters. It is important to note that this scale does not determine coping styles or traits, but instead looks at the coping processes in a particular stressful encounter, with consistency (or style) across occasions evaluated through repeated administering of the scale.

Previous research by Folkman and Lazarus (1985) has identified eight coping scales from the inventory: five of which are classified as emotion focused, one problem focused scale, and a scale considered to be both problem focused and emotion focused. Internal consistencies for the subscales range from alpha 0.61- 0.79 (Folkman & Lazarus, 1985). These scales and an example of each statement include:

- Problem focused coping: ‘I try to analyse the problem to understand it better’
- Wishful thinking: ‘I hoped a miracle would happen’
- Detachment: ‘I accepted it, since nothing can be done’
- Seeking social support: ‘I talked to someone to find out more about the situation’
- Focusing on the positive: ‘I tried to look on the bright side of things’

- Self-blame: ‘I criticised or lectured myself’
- Kept it to self: ‘I kept others from knowing how bad they were’
- Tension reduction: ‘I jogged or exercised’

The inventory is scored on a Likert Scale from 0 = ‘Not used’, up to 3 = ‘Used a great deal’. Each of the eight coping strategies were calculated by taking the average responses for each question. The main advantage of this questionnaire is the quantification of a coping process that can be considered as multi-faceted as through other means of data collection (Lazarus, 2002).

4.2.3 Procedure

Before the commencement of data collection, initial approval was obtained from the Northumbria University School of Life Sciences ethics committee. After detailing the nature of the study and how the results would be disseminated, further approval was granted from the senior learning and development manager, training centre manager, and area manager responsible for service delivery of the participating fire and rescue service

The training class was spoken to as a group by the lead researcher while at training school (although the lead researcher was not in uniform) detailing the nature of the study, and then provided with an ‘information for participants’ booklet. They were informed that the study would be taking place alongside their SCBA training exercises and that if they would like to take part they were to e-mail the lead researcher within the next 14 days.

Prior to involvement in the study all participants were provided with, read and signed an informed consent form provided by post and approved by Northumbria University’s School of Life Sciences ethics committee. This form was returned to the lead researcher via pre-post envelope. Informed consent was provided away from the course instructors at the training school to prevent peer pressure to participate. Participants were informed that all questionnaires were to be self-completed in their own time, but their completion was extremely important to the study.

In addition, training school instructors were not informed as to how many participants, or any information about who specifically was taking part in the study, although they were made aware that a study was being undertaken and what the investigative aims of the researcher team were. Although the lead researcher for this project was also an employee of the same fire and rescue service as the participants, he had no direct contact with them during the course of a normal work routine, and therefore there was no additional pressure upon the participants to take part.

Data collection utilised a longitudinal approach, as previous research such as Nicholls et al. (2006) has suggested that longitudinal research is conceptually coherent with process oriented theories of coping. Such designs are considered to help establish the change processes associated with coping and stressors over time and will seek to explore if the tasks, demands, and coping differ from being a recruit to one years' full operational service. When assessing coping, Ptacek et al. (2006) recommend the use of measurement tools that consider real-situation specific coping responses repeatedly over time, such as the diary approach utilised by Nicholls et al. (2006) when assessing longitudinal stressors, coping and coping effectiveness in rugby players. This method provides the advantage of greater power than cross sectional studies, although causal relationships still cannot be established.

Based upon this, participants received a study booklet during the final Friday of each calendar month while at training school following the completion of breathing apparatus tasks during this month as part of a compulsory component of their breathing apparatus wearer's course. Although the start point for this study was week nine of their initial firefighters' training course, data collection prior to October was not considered as participants had not yet started their SCBA training.

When on station, questionnaires were provided on the last Friday of the quarterly period, and were focused upon the most demanding task that they had faced for that month / quarter. The disparity in data collection timings is due to the extensive number of SCBA tasks required to be undertaken whilst at training that also incorporated their first ever SCBA exercises under ambient temperatures during October 2010, and their first experiences of wearing SCBA under live five conditions in November 2010. However, when on station there is only a requirement to undertake SCBA tasks at least once every three months. Therefore, the use of monthly data collection on station may not produce any results for two of every three questionnaires sent, whilst a quarterly collection would guarantee that SCBA had been worn at least once during this time period.

Upon completion of the booklets at each stage of data collection by participants, the questionnaire was sealed in a pre-paid envelope and returned to the lead researcher within one week of completion. All questionnaires received were returned within this one week period.

4.2.4 Treatment of data

In keeping with the recommendations of Cohn et al. (1998), who endorse the use of qualitative and quantitative methodology when analysing the results and information provided by participants involving emotions present during crisis scenarios, two types of data analysis was undertaken. First, a qualitative based method for the unstructured responses to demanding scenarios and situation specific stressors; and second a quantitative method for examining the structured questionnaires measuring coping style, demand, background stress, and performance. Analysis of all data took place once the final questionnaires had been received.

Data collection took place over a 12 month period. From 14 participants, a total of 41 completed question booklets were returned out of a possible 70 (58% completion rate). Study collection dates and return percentages at each stage, and for each participant are displayed in table 4.1:

Table 4.1 – Questionnaire response rate by participants (as demonstrated by an 'X') during each stage of data collection over a 12 month period.

Collection stage	No. (and %) returned	Participant ID													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1- Training School (Oct 2010)	11 (79)	X	X		X	X	X	X	X	X	X	X	X		
2- Training School (Nov 2010)	12 (86)	X	X		X	X	X	X	X	X	X	X	X		X
3- On station (Jan-March 2011)	7 (50)	X				X		X	X	X		X	X		
4- On station (April – June 2011)	5 (36)	X				X			X			X	X		
5- Training School (July - Sep 2011)	6 (43)	X	X			X			X			X	X		

Due to the unstructured nature of the responses accredited to the qualitative phase, it was first important to remove any information of a legal or sensitive nature, such as specific names, addresses or details of operational incidents.

To ensure consistency with the methodology employed in Chapter 3, a two stage process was then employed to the descriptive qualitative responses to questions 1-5. First, tags were created by the researcher by dividing the text into segments that contained a piece of information, before categories were created from these tags by labelling clusters with similar meanings. Two broad themes were used, with one for 'type of task' and another for 'stressors'. Open ended responses were then coded into each of these areas and then grouped together and assigned into broad first order themes and then further as a second order theme with a descriptive label by the lead researcher.

As in Chapter 3, the use of peer review formed an important aspect of the data analysis. The use of a peer review by someone familiar with the research is considered to provide support, play devil's advocate, challenge the researcher's assumptions, push the researcher to the next step methodologically, and asks hard questions about methods and interpretations (Lincoln & Guba, 1985). Most importantly, by seeking the assistance of a peer debriefer, credibility can be added to the study (Lincoln & Guba, 1985).

Emerging themes were then classified as descriptive or higher order categories. In order to ensure validity of the data, procedures recommended by Sparkes (1998) were utilised and adapted for the needs of the sample. Within this study, this included two occupational experts (one a senior member of staff responsible for the implementation of breathing apparatus exercises within the organisation, and another with a remit for trauma support services of firefighters). Both examined all of the raw data independently and held structured meetings to discuss observed similarities and differences, as well as exploring multiple interpretations and discrepant findings, until a 100% consensus was obtained through argument and agreed by the experts.

Each of the structured questionnaires were scored according to the prescribed guidelines to gather mean values and standard deviations for each construct. However, following exploration of data for each of the variables utilising stem and leaf plots, results were found to be non-parametric and assumptions about normal distribution had been violated. As a result, data are reported as medians and interquartile range, although means and standard deviations are provided in appendix E.

4.3 Results

The primary focus of this study was threefold. First, the identification of the stressors associated with firefighting tasks; second the impact upon self-rated performance measures, and finally the coping styles employed.

4.3.1 Identification of stressors

A total of 123 qualitative responses were stated by participants, comprising 32 unique stressors over the 12 month period. A number of responses were similar in context (for example physical fatigue of managing hose, and physical demands of carrying charged hose) and as such each of the stressors were further categorised into five primary stressor categories: physical demands of the environment, cognitive / psychological demands of the task, technique based approaches, observation/assessment stress, and novel situations. These categories could account for 100% of all responses. Figure 4.1 provides a graphical presentation of the total citations of each category as a total of the 12 month data collection period, and figure 4.2 presents the stressors at each stage of data collection.

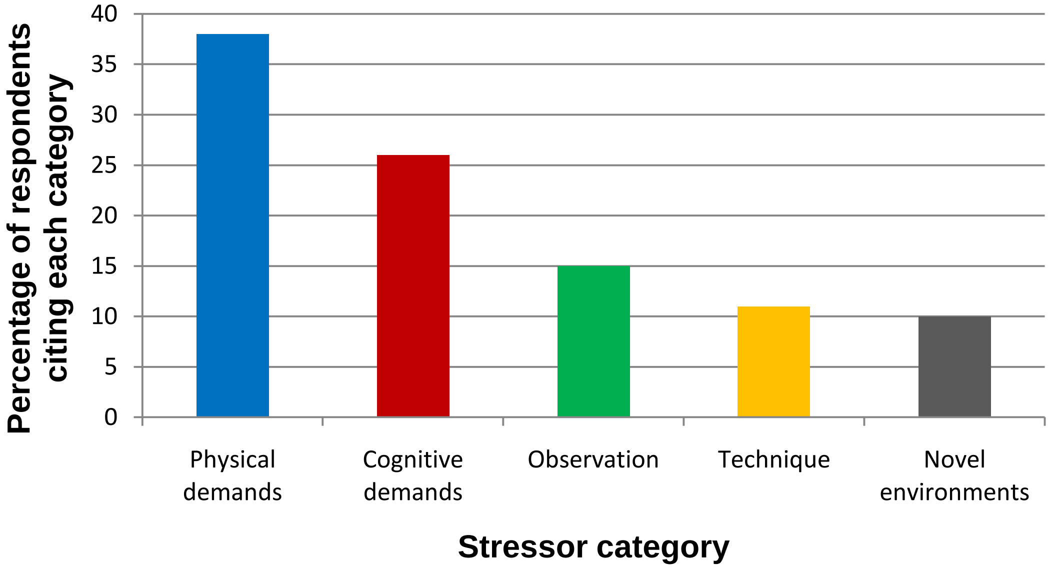

Figure 4.1. Percentage of total stressors reported by firefighters over a 12 month period.

4.3.1.1 Physical demands

The most commonly reported stressors over the 12-month period could be categorised as the physical demands of firefighting whilst wearing SCBA, with 38% of all stressor responses being described as compromising physical demands in some way. This category was further sub-categorised to include the demands of working in extreme heat that accounted for 49% of physical-specific stressors. The remaining five task specific demands categorised as a physical stressor included managing / carrying / hauling charged hose (30%), carrying casualties to safety

(8%), climbing ladders (6%), the biomechanical / movement difficulties of wearing SCBA (4%), and working in a confined space (2%).

4.3.1.2 Cognitive demands

Stressors related to the cognitive demands of firefighting were found to be present at each of the stages of data collection over the 12 month period, and contained 26% of all stressors. Within this category, one response dominated, with 'obscured vision' accounting for 34% of all cognitive demand responses. A further range of eight other facets were also categorised as a cognitive demand, including maintaining concentration (16%), knowing there were persons trapped inside the building (13%), degradation of hearing (9%), knowing they were responsible for others (9%), fear of burns and injury (6%), having to work as a team (6%), time pressure (3%), and frustration (3%).

4.3.1.3 Observation and assessment

Stressors categorised by observation or assessment stress accounted for 15% of total stressor responses. The specific 'observation and assessment' stressors included 18 individual responses that could be categorised into two observation stressors. These included pressure to pass the assessment (61% of all responses considered an observation/assessment stressor), and being directly observed by training officers and senior fire service officers (39%).

4.3.1.4 Technique

Technique considerations comprised 11% of total responses over the 12 month period, and were further broken down into six types of techniques. The most prominent subcategory was the identification of ineffective or inefficient techniques of using the branch (the nozzle at the end of the hose that controls the direction, type of spray, and output of water), both when extinguishing fire and controlling fire gases representing 50% of all responses within this category. A further four types of stressors were also identified considered to be technique based, including casualty handling techniques (21%), avoiding trip hazards (14%), tying knots (7%), and the management of hose into a building (7%).

4.3.1.5 Novel environments

The least cited stressors contributed to the novel environment category, compromising 10% of all responses from the firefighters. Further subcategorisation of this area identified that wearing SCBA for the first time at a real incident accounted for 50% of the all novel environment stressors. Novel stressors also encompassed the first time they had undertaken a task in a position of responsibility (27%), use of new equipment for the first time (8%), exposure to a new environment (8%), working with new people (8%), and the first time undertaking a task without a SCBA instructor present to act as a safety officer (8%).

4.3.1.6 Occurrence of stressors

In terms of stressors over the twelve month period, a graphical representation of the percentage of the responses at each data collection stage is presented in figure 4.2. Responses revealed that physical demands were considered most demanding when participants were at training school (data collection stages 1, 2, and 5), and consisted of 37%, 52%, and 39% of all stressor responses for that data collection stage. When on station, cognitive demands were identified as being most prevalent during data collection stages 3 (33% of all coping responses for this stage) and 4 (42%).

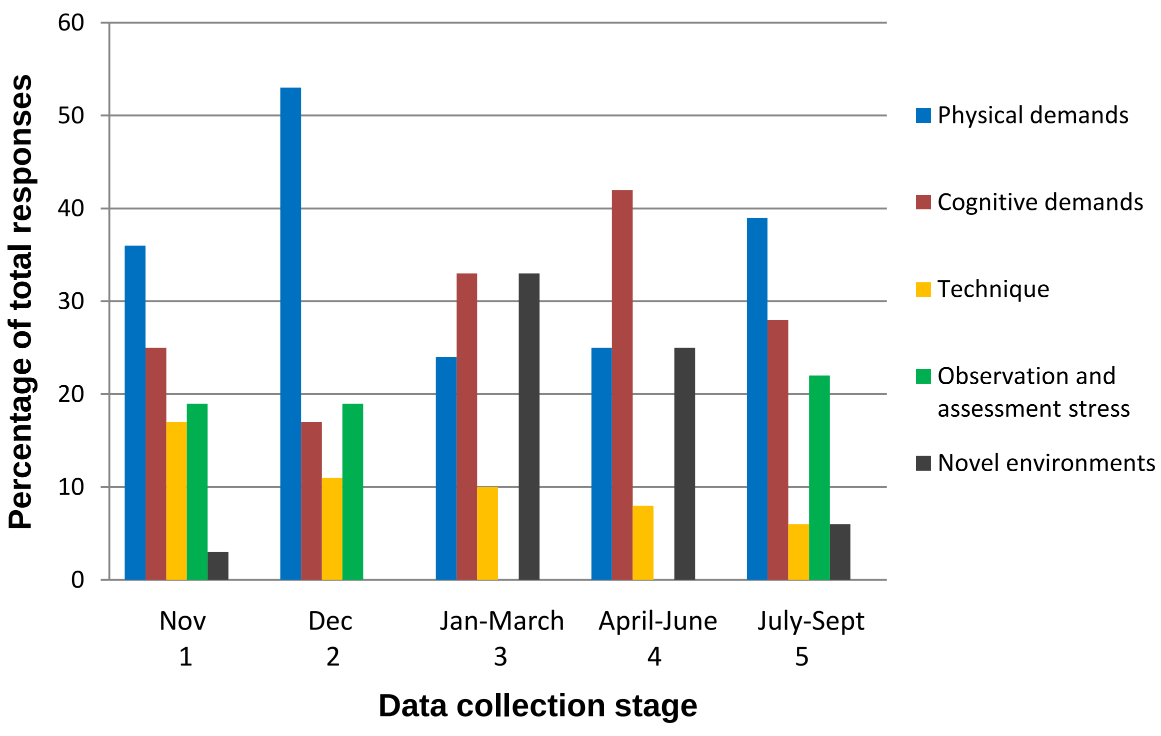

Figure 4.2. Percentages of stressors reported by firefighters during each stage of data collection over a 12 month period.

Any concerns relating to specific aspects of technique declined steadily across the year, ranging from 17% at the beginning of the year, to 6% upon completion of data collection. By contrast, only minimal numbers were stated during November when at training school (3% of total stressor responses for that stage of data collection), no activities considered by participants as having a novel demand during December, and only a minimal number on return to training school at 12 months service (6%).

Observation and assessment stress was only reported during the three occasions participants were at training school, and was consistent during these stages with these stressors accounting for 19% (during data collection stage 1), 19% (data collection stage 2), and 22% (data collection stage 5) of total stressors stated at that stage. Finally, stress from novel situations was found to be greatest during the first three months on station (33% of the total stressors reported at this stage), and the following three months on station after this at stage 4 (25% of total stressors reported at this stage).

4.3.2 Subjective performance measures

The four ‘subjective performance measures’ were measured using scales ranging from 0-100 and included the following constructs: the level of control they perceived themselves as having over the task (CT); effectiveness in coping with the demands of the task (CE); how tough the task was in terms of previous experience (TS); and overall satisfaction of performance (SP). Each produced a median score demonstrated in table 4.2:

Results indicated that even in early career this sample of firefighters considered themselves to have a high degree of control over demanding tasks faced, were very satisfied with their performance despite stressors encountered, and were able to cope with the specific demands of the task despite them being considered to be some of the most severe they had encountered.

Subjective measures of performance related specifically to individual perceptions of the stressors that existed during the task, and not simply the type of task undertaken. The two measures of control over task (CT) and satisfaction of performance (SP) demonstrated a similar trend characterised by a decrease between data collection points one (CT median = 70; SP median = 78) to two (CT median = 60 ; SP = 70) before rising at data collection point three (CT = 70; SP = 80) and decreasing at data collection point four (CT = 60; SP = 70) before rising again and peaking at 12 months service (CT = 76; SP = 83).

Of the five stages of data collection, participant information collected at the 12 month point demonstrated that, despite representing the highest reported medians for task severity (77), participants stated that they perceived themselves to have the most control over the task (76), satisfaction of performance (83), and coping effectiveness (84).

Table 4.2. Self-reported medians (and interquartile range) of the four subjective measures of performance reported by firefighters during each stage of data collection over a 12 month period.

	Data Collection Stage				
	November (1)	**December (2)**	**Jan-March (3)**	**April – June (4)**	**June – Sept. (5)**
Control over task (CT)	70 (25)	60 (23)	70 (25)	60 (35)	76 (16)
Coping effectiveness (CE)	75 (30)	75 (20)	80 (20)	70 (15)	84 (21)
Task severity (TS)	70 (60)	73 (29)	60 (25)	75 (29)	77 (38)
Performance satisfaction (SP)	78 (30)	70 (28)	80 (15)	70 (34)	83 (21)

The least severe task faced during the twelve month period was at 6 month service (January to March) and was characterised by increases in the stressors of cognitive demands and novel environments, which were associated with high levels of coping effectiveness (median = 80) and performance satisfaction (median = 80). At no stage of the study did the median scores for participants coping effectiveness fall below 70 (out of a max of 100), indicating extremely high levels of perceived coping effectiveness.

4.3.3 Coping Style

Self-reported coping styles in response to the stressors provided eight separate constructs at each stage, and were scored depending upon how frequently the firefighter reported the construct. Again, due to the skewedness of the data, medians and interquartile ranges at each data collection stage are displayed, and descriptive statistics are used to explore the data. Data from each stage are presented in table 4.3.

Information collected suggests that the trainee / probationary firefighters involved in this study used a range of all eight available coping strategies when faced with high demand. The construct of ‘keeping things to self’ was the only coping style that scored 0 and was reported as ‘not being used at all’ (between April and June), and no coping styles scored higher than 2, considered to be ‘used quite a bit’, suggesting that all techniques were utilised in limited and varying extents at each stage of data collection.

Table 4.3. Self-reported medians and (interquartile range) of eight coping strategies reported by firefighters during each stage of data collection over a 12 month period, as measured by the Ways of Coping Checklist (WOC).

	PFC	**WT**	**DET**	**SOCS**	**FPOS**	**SBLA**	**KTS**	**TRED**
November (1)	1.45 (0.45)	1.20 (1.00)	0.50 (0.83)	0.86 (0.86)	1.25 (0.50)	1.33 (1.33)	0.67 (0.67)	0.49 (0.71)
December (2)	1.13 (1.07)	0.50 (0.95)	0.58 (0.50)	0.86 (0.71)	1.00 (1.25)	1.33 (1.25)	0.67 (0.92)	0.42 (0.67)
Jan-March (3)	0.91 (0.73)	1.00 (1.00)	1.00 (1.50)	0.71 (1.00)	0.75 (1.00)	0.67 (1.00)	0.67 (0.67)	0.86 (0.71)
April – June (4)	0.96 (0.91)	0.30 (0.75)	0.17 (0.38)	0.64 (0.68)	0.87 (0.63)	1.50 (1.75)	0.00 (0.50)	0.17 (0.50)
June – Sept (5)	1.78 (0.55)	1.10 (1.35)	0.92 (1.21)	1.21 (1.00)	1.62 (1.19)	1.33 (0.75)	1.33 (1.17)	1.33 (0.75

Note: PFC=Problem focused coping; WT= wishful thinking; DET = detachment; SOCS = Social support; FPOS = focusing upon the positive; SBLA = self-blame; KTS = Keeping things to self; TRED = tension reduction

When at training school between data collection stages one and two, participants reported most frequent usage of problem focused coping (medians = 1.45; 1.13) and self-blame (medians = 1.33; 1.33). As with data collection stage one, on return to training school at twelve months service, problem focused coping again became the highest perceived level of usage (median = 1.78), with detachment reported least (median = 0.92). Whilst problem focused coping and self-blame were most present during training school, detachment (median = 1.00) and wishful thinking (1.00) were utilised most often during data collection stage three, with data collection stage four associated with self-blame as the dominant coping construct (median = 1.50).

It was also found that detachment (median = 0.50) and tension reduction (0.49) were considered the least used coping strategy at data collection stage one, tension reduction (0.42) was least used at data collection stage two, self-blame (0.67) and keeping things to self (0.67) was least used at data collection stage three, with no reported usage of keeping things to self at data collection stage four, and detachment least at the end of the study (0.92)

Typically, six of the eight constructs (problem focused coping, social support, focusing on the positive, self-blame, keeping things to self, and tension reduction) were perceived as being used to the greatest extent at the end of the data collection period, with wishful thinking peaking at data collection stage one (median = 1.20), and detachment at data collection stage three (1.00). No specific stage was associated with the least use of any of the coping styles, although five of the constructs were reported minimally between 6 and 9 months on station (wishful thinking (median = 0.30), detachment (0.17), social support (0.64), keeping things to self (0.00), and tension reduction (0.17)), with the remaining three constructs dipping at 3-6 months service (problem focused coping (0.75), focusing on the positive (0.75), self-blame (0.67)).

The use of wishful thinking demonstrated a pattern of relatively high usage followed by relatively low perceived usage, with medians dropping from 1.20 to 0.50 before rising to 1.00 and then dropping to 0.30 before rising again to 1.10 across the twelve month period. The remaining constructs did not show any real patterns over the twelve month period, with no consistent rises or falls, nor the demonstration of any ‘u’ (or inverted-u) -shaped relationships across the study period.

4.4 Discussion

4.4.1 Overview

A total of fourteen newly appointed wholetime firefighters, representing the trainee cohort of the same urban metropolitan fire and rescue service, took part via postal questionnaire booklets. It was hypothesised that over a twelve month period trainee / probationary firefighters exposed to SCBA tasks would show a steady increase in perceived control, and perceived effectiveness of their ability to cope. It was also predicted that these firefighters would demonstrate greater perceived levels of satisfaction with their performance in the task they had described as the most demanding of that data collection stage. Severity of the task experienced was expected to peak following first exposure (e.g. first hot wear at training school, and first real life incident on station) before also steadily decreasing as a result of prolonged exposure, increased experience, and familiarity. However, the wide range of stressors reported by experienced firefighters in chapter 3 of this thesis suggests that there would be extensive and high levels of stressors perceived by participants regardless of the task.

There was also expected to be a wide range of coping strategies utilised during the participants' time at training school and when first placed on station, with a number of 'dominant' or preferred coping styles present and 'used a great deal' at each subsequent stage. Furthermore, other coping strategies considered less effective, would demonstrate a steady decline over the twelve month period. However, none of the hypotheses were supported amongst this sample of newly appointed firefighters.

4.4.2 Stressors

Of the five unique categories relating to the stressors and demands of wearing SCBA, those considered to contain either physical or cognitive stressors accounted for almost two thirds of all stressor responses over the twelve month period. These findings are in line with previous research assessing these factors in other populations, such as Nicholls et al. (2007) who report how despite athletes appraising a wide range of stressors over a longitudinal study period, a number of stressors consistently re-occur over time (Nicholls et al., 2007). Similar findings have also been observed in a study of 59 trainee firefighters enrolled on a six-week beginning firefighting course, where individuals who reported being able to distinguish and identify their emotions, reported fewer cognitive difficulties, leading to better functioning in acute stress situations due to more attention being focussed on the task (Gohm et al., 2001).

The physical demands of tasks reported by firefighters in this study, including having to work in extreme heat, were found to be most profound during tasks experienced at training school, whilst cognitive demands (such as obscured vision and maintaining concentration) were stated as being most frequent during operational periods. These findings were not surprising given the physiological and psychological demands associated with working in hot environments likely to consistently be over 150^{o} C (Love et al., 1996), and the increased cognitive demands of multi-stressor environments such as deficiencies in reaction time, memory, and reasoning (Lieberman et al., 2005). The findings were also consistent with Bryant and Guthrie (2005) who reported that early career firefighters perceived fires to be the most demanding tasks faced in the fire service. Increased levels of cognitive demands at operational incidents may be expected due to the consequences of making a mistake that could lead to significant risk of injury, death or failure to meet the incident objectives (such as the rescue of persons trapped). Whilst there would have been high levels of cognitive demand produced at training school, the firefighters will be aware that there are always safety officers in attendance if required, and as such the actual consequence of failure is not comparable to that experienced outside of training school.

The reports of observation related stressors was an interesting finding, given that such effects were not reported by any participants when away from training school. Gendolla and Richter (2006) suggest that social observation during task performance makes success more important, because the physical presence of an observer is sufficient to induce a state of social evaluation resulting in psychological stress reactivity such as cardiovascular and endocrine responses (Dickerson & Kemeny, 2004). Observation effects have also been reported by Police recruits, who have reported greater feelings of stress as a result of confronting an unknown situation related to their future career whilst being aware that their performance was being evaluated (Regehr et al., 2008).

Despite participants being in a ‘honeymoon’ period (Regehr et al., 2003), where the initial stages of work involved working together to attain the same goal and status resulting in a greater deal of camaraderie, all assessments needed to be passed. As a result, any observation stress may be augmented by knowing that the observing officer was not only watching them, but also their colleagues, and that a mistake by another member of the group could lead to the failure of the whole team for that exercise. Further research is encouraged to identify if any coping strategies used to manage social evaluation or observation stressors are applicable to other firefighting demands, or are even required on station.

In terms of exposure to novel environments, It is important that trainee firefighters utilise training school to establish and identify optimal coping strategies for dealing with novel environments, and for training officers to be aware of this process in order to facilitate successful and safe performance by the firefighter when attending operational incidents. According to Sommer and Nja (2011) the goal of the training environment is, therefore, to ensure that knowledge is generalised so that it can be applied in situations that resemble experienced / training situations. The researchers suggest that firefighters within the training environment must be able to recognise typical signs of operational environments they will encounter and must be able to evaluate the consequences of their own behaviour and recognise whether it is effective or not. Overall, very few stressors related to exposure to novel environments at training school despite their high perceived frequency at operational incidents. Future training environments should therefore consider a focus upon situations novel to participants, but where the assessment and observation is more covert by training officers.

None of Beaton et al.'s (1998) five identified components of on duty stressors (catastrophic injury to self or co-worker, gruesome victim incidents, rendering aid to seriously injured, vulnerable victims, minor injury to self and exposure to death and dying) were identified. Similarly, the incident related stressors reported by Baker and Williams (2001) that included concerns about safety of oneself and colleagues, handling dead bodies, and attending a chemical incident were cited by the firefighters in this study. However, this may be because the sample were yet to experience incidents of this nature, and not as a result of them not being considered stressful. Furthermore, the presence of such incidents and stressors would not be expected to be experienced at training school.

4.4.3 Coping

To cope with the identified demands, firefighters reported the use of eight coping strategies identified by the Folkman and Lazarus (1985) Ways of Coping Questionnaire (WOC) at each stage of data collection. Of the eight strategies, both 'problem focused coping' and the use of 'self-blame' were used to the greatest extent by participants over the twelve month period, and overall there was less usage of detachment and tension reduction compared to other strategies, although there was no single dominant strategy present at each of the five stages data was collected. The tendency of an individual to assert control over a situation is also likely to be manifested in the coping strategies incorporated, whereby individuals exposed to a stressor are more likely to react in a constructive fashion such as through problem focused strategies (Giankos, 2002). However, due to the different coping strategies reported to be effective at different times in different contexts, both a range of problem and emotion focused approaches (such as the self-blame reported in this study) are recommended and likely to have their uses (Nicholls et al., 2006) for the individual environment.

The range of coping strategies used by the sample were consistent with athlete focused research (i.e. Tamminen & Holt, 2010), demonstrating that there are often a variety of coping strategies to with deal combinations of stressors, and that these are often used in combination with each other. The research of Tamminen and Holt (2010) also suggests that there are stressors that require multiple coping strategies that are selectively applied, resulting in strategies that are rarely used uniformly across all stressors, offering further support for the type of coping being used in a 'transactional' manner. Lazarus (2002) suggests that both problem and emotion focused methods will work together to supplement each other in the overall coping process and it is highly unlikely that just the one coping style will even be used independently, as was found in this study and earlier research in chapter 3.

There was a wide range in levels of coping usage over the twelve month period, with some firefighters reporting that they use certain coping strategies 'quite a bit', whereas some reported 'never' using them at each stage. Similarities in the coping styles at training school have also been demonstrated with athlete samples during training sessions. For example, Crocker and Isaak (1997) found consistency in coping style where sessions were very similar, held in the same place, and represented a single phase of the training programme. The researchers found that there was very little consistency in coping style in competition situations, as was the case in this study, and provides evidence against a 'preferable' or idealised coping strategy. This suggests that the coping skills learned developed through training may not be compatible with real life incidents, as each incident has different meaning for the individual who adjusts accordingly. However, Ptacek et al. (2006) state that although current evidence for cross-situational coping consistency is not compelling, neither is it totally lacking, and as such further research is recommended to examine if operational incidents appraised the same by firefighters do actually produce consistent coping strategies. In this study there were only two opportunities for the firefighters to report stressors found at operational incidents, both of which contained varying levels and types of stressors.

The greatest use of all coping strategies occurred at the final stage of data collection, when the firefighter's returned to training school for competency assessments, and this was expected due to the increase in the participant's performance accomplishments including successfully managing the stressors of past experiences using coping strategies. This would also have included the likely extensive (6 month duration) integration with experienced firefighters on their station. Sommer and Nja (2011) describe how procedures, working methods, tools and equipment, along with mutual insights and knowledge are all used when new firefighters interact with experienced firefighters on their watch and learn how to do things according to common fire service practice. Common practice amongst experienced firefighters is closely related to what new firefighters regard as meaningful, and as such new firefighters will 'imitate' experienced firefighters in order to carry out the work in the most appropriate and effective way. Even by listening to the stories that are told on station by experienced personnel, new firefighters learn more about the correct actions to undertake at incidents, and how to think and interpret situations by observing the more experienced personnel on the watch. Because each of the experienced firefighters on the probationary firefighters watch is still expected to attend training school a number of times each year for training any advice, stories, or interaction with the experienced firefighter will provide the recently qualified individual with additional resources on how to deal with a situation they had experienced previously such as SCBA wears at training school.

4.4.4 Subjective measures of performance

Firefighters are reported to hold a strong belief in control, a high degree of confidence, and a low sense of helplessness in problem situations, with a tendency to approach rather than avoid problems (Baker & Williams, 2001), and as such a consistently high level of control was to be expected from the firefighters in this sample. Similarities between increased control and performance satisfaction have been established in occupation occupational settings (Rotter, 1966), and similar results were found in this study. During tasks that were considered to be more 'severe' by participants, there was a demonstrated decrease in perceived control and performance satisfaction by the firefighters. This may have been as a result of the firefighters' inexperience in exercising control and observing others exercising control in severe environments, but may still to develop over time and experience attending 'severe' environments. Alternatively, as feelings of low perceived control have been associated with reduced job performance in other occupational settings (Judge & Bono, 2001), within this study the decreased feelings of perceived feelings of control may have led to reduced job performance of the firefighters who may then have reported reduced ratings of performance satisfaction as a result of this job performance.

The effectiveness of coping methods utilised were perceived by the firefighters in this study as being effective throughout their first year, and were associated with corresponding increases and similar levels of performance satisfaction. This suggests that trainee and probationary firefighters may innately possess a number of skills identified in the Jones et al. (2002) definition of 'mental toughness', such as control under pressure in response to the demands placed upon them. However, there still remains a great deal of debate as to the conceptualisation of what mental toughness really is, even before preliminary links are made to the existence of mentally tough skills in emergency workers or firefighters. The framework of Jones et al. (2002) was developed solely from data derived from athletes, and utilised a single focus group with only three follow up interviews. Given this limited methodology, further exploration and validity is required before the mental toughness framework can be applied to firefighters.

The finding that physical and cognitive demands were comparable between training environments and real life incidents can be considered a validation of the effectiveness of the training exercises devised by the training school officers, and this suggests that the participants from this sample were able to experience such effects in a controlled environment before being posted to a fire station. Graveling (2001) suggests that although the use of exposure to elevated temperatures during training is a hazard to which firefighters and instructors are exposed, it is essential that firefighters are trained to cope with the dangers they may encounter at incident and therefore some risk can be regarded as justifiable. In this instance and with this population, the risk can be justified to expose the trainee firefighter not only to physical stress but also cognitive demand.

Previous research into extreme environments by Weston (2012) has found that exposure to situations likely to be encountered (including physical, technical, tactical and psychological demands) through simulation is considered invaluable, and allows the individual to establish their personal capabilities, be more aware of the consequences of their actions, and identify the line between performance and safety. Further benefits include the opportunity to initiate different coping strategies and evaluate their effectiveness in dealing with the demands faced, as well as the increases in confidence and motivation when encountering stressful environments achieved as a result of being able to draw on past experiences of that environment (even when undertaken as a training scenario) (Weston, 2012). This is directly applicable to firefighting, where exposure and experiences at real-life incidents cannot be predicted or planned for, and as such the use of training / simulation are instead used to prepare firefighters for the demands likely to be encountered at operational incidents (Sommer & Nja, 2011).

4.4.5 Methodological considerations

This was one the first studies to consider the longitudinal measurement of stress, demand and coping responses that occur during the first 12 months of a firefighters career whilst wearing SCBA, and the first to consider a range of factors, aside from the incidents that result in traumatic stress or serious stress symptomology (i.e. Brown et al., 2002). As a result, this study provided an example of a compromise between best-case methodological procedures and the assessment of real issues, in a real sample in real time. Based upon this, the current findings must be viewed in light of a number of methodological considerations.

4.4.5.1 Attrition rate and socially desirable responding

The most prominent limitation of this study was the attritional rates of the participant sample. As might be expected in a longitudinal study, there was a considerable reduction in participant rates, but moreover, a lack of consistency in those completing question booklets at each stage of the data collection. It may be the case that those participants who struggled to make the transition from trainee to probationary firefighter were unwilling to disclose any difficulties or demands they had for fear of retribution or the results affecting their career. However, of those who responded, all demonstrated a willingness to disclose a range of events and coping styles.

The study was also limited by the small number of participants, particularly during the mid-stages of data collection when questionnaire returns fell to under 30% which therefore limited the use of inferential statistical analysis. These attrition figures are comparable to other researchers such as Dowdall-Thomae (2009) who reported a 31% questionnaire completion rate; albeit from a considerably larger sample of 170 US firefighters. Similarly, Nicholls (2010), in reflections of three previous studies, has reported a drop out rate of up to 60% amongst athletes, with the use of a 'diary' approach relying heavily upon the researchers' enhancing adherence from participants. Techniques such as meeting participants on a regular basis or sending SMS messages as reminders (Nicholls & Ntoumanis, 2010) have all been suggested and should be considered if further longitudinal firefighter research is considered.

A primary strength of the longitudinal research approach utilised in this study is that it allows researchers to try and predict later events from measures obtained earlier, through repeated measures on the same persons across diverse circumstances. This process allows for the identification of stable traits and for monitoring of any changes (or processes) in reactions over time (Stone et al., 1991). However, within this study there were multiple indices of participants opting in and out of participating in the study over the data collection time period (as presented in table 4.1). For example, although five participants completed data at each of the five stages, participant number 5 only completed at stages 1, 2, and 5. Hence, the presentation of descriptive statistics was deemed the most appropriate method for presenting this data.

The participant group in this study represented the recruit class of the participating FRS, making increased participant numbers impossible without the introduction of another recruit class. Based upon information provided by the FRS used in this study, this was the first trainee course to be run for over two years with no further courses or recruitment planned. The utilisation of other FRS recruit courses was also unknot feasible due to different course durations, pass criteria, and the use of live fire as a training method (a further exploration of the usage of live fire training in the UK will be presented in chapter 5). However, total numbers for this study were comparable with related sport research using longitudinal designs, including season long studies of 13 female basketball players (Tamminen & Holt, 2010) and month long measures of five rugby union players (Nicholls et al., 2009).

With the participants being spread across four duty watches and at 12 different fire stations, it is unlikely or rare that they would encounter each other at operational incidents. At training school however, they were working together each day and undergoing tasks as a unified group. It stands to reason therefore that when completing the questionnaires at training school there was more of an acceptance by the trainees that tasks were difficult and that it was acceptable to admit this on the questionnaire, since many others on the course may have also thought the same, and the tasks were designed to push limits. On station however, a combination of more experienced firefighters and a more diverse range of incidents may have resulted in participants being less willing to disclose a task as demanding if more experienced personnel on watch did not perceive it as demanding.

There is also the risk of socially desirable responding amongst participants previously identified in research, where firefighters' responses are related to the tendency to respond in such a way as to present themselves more favourably, to serve their own self-interest, or provide what they consider the responses the researcher wants to hear rather than a truthful answer (Razavi, 2001). This can be conducted either deliberately or subconsciously, and is thought to be influenced by the setting the research is conducted and the participants' belief about the purpose of the research, in particular if personnel also believe that their responses may influence occupational factors such as pay, promotion, or job security. In studies examining occupational stress, this idea of 'deliberate misinterpretation' may include the participant making a positive presentation of themselves ('faking good'), or making things look worse than they are to produce a desirable outcome such as an alternate or reduced workload (Razavi, 2001), although subconsciously the individual may also use these methods to create a positive impression, avoid criticism, or gain positive approval from peers (Crowne & Marlowe, 1964). Baker and Williams (2001) suggest that within their sample of UK firefighters, social desirability factors may have been an important factor due to the culture of the fire service, which instils a firefighter 'identity' that is characterised by stoicism and self-discipline that may consequently lead to lower self-reporting of stress and adverse psychological reactions. In emergency organisations, particularly firefighting, Baker and Williams (2001) also suggest that there is a tendency for personnel to employ a professional 'armour' in order to distance themselves from the most disturbing and stressful aspects of their jobs.

Furthermore, given that the principal researcher of the current study is an officer in the same fire and rescue service as the participants, it is possible that the firefighters may have been fearful of not completing the questionnaires in case it impacted upon their employment. As time progressed and the firefighters were posted onto stations and started passing internal skills and knowledge assessments, they may simply have been unwilling to disclose this due to a lack of incentives or reluctance to disclose that they found tasks stressful. For example, in a study using a questionnaire designed to elicit information on personal experience of stress and stress-related problems in military commanders, Cawkill (2004) distributed a total of 9,020 questionnaires between the three Military Services. The researcher found that although most respondents accepted that stress and stress-related problems exist, they were reluctant to disclose their own stress-related problems or seek help for fear that it might be detrimental both personally and professionally.

4.4.5.2 Recall of events

The timing of each data collection point should also be considered, in particular the time variances in firefighters' retrieval of the stressful scenario. However, the optimal time for participants to accurately report instances of coping remain open to debate. Giacobbi and Weinberg (2000) have acknowledged the problem of retrospective reports associated with recall bias and errors, recommending that repeated measures of coping are made as close to events as possible to increase the validity of investigations into coping. Nicholls (2011), when describing the limitations of studies using retrospective recall describes how asking participants to recall a stressor that had occurred in the past 14 days (as used by Kaisler et al., 2009) cannot accurately recall the coping strategies deployed, with some people forgetting the coping strategies used whilst others over-report the coping strategies used.

Alternatively, it has been suggested that daily measurements of coping do not allow participants sufficient time for reflection regarding their coping (Folkman & Moskowitz, 2004), with research by Ptacek et al. (1994) demonstrating a 26% variance between coping responses in individuals when using daily and weekly reporting measures. Within this study, the initial plans to measure the factors on a monthly basis were changed to a quarterly basis to match the current training guidelines for the fire and rescue service that was used for this study (stating that a firefighter must wear and undertake a number of breathing apparatus training tasks every three months). In short, with measuring coping monthly there was no guarantee that they would have worn SCBA or undertaken a SCBA task. Similar to this, Dowdall-Thomae (2009) found that even incorporating data collection periods of 20 working days (around two months) was insufficient time to capture firefighters' attendance at specific types of operational incident and enable the collection of coping measurement. However, although three-monthly data collection increases the likelihood of a SCBA task, accounts may be based on activities that occurred up to 90 days previously. Daily, end-of day accounts may have provided a more accurate measure of both the task and coping measure; however this would have placed a considerable burden on participant time and may have increased the attritional rates of participants.

A study allowing for more time and allowing firefighters to recall incidents that occurred with close proximity from their distant past may increase the levels of accuracy and reliability when recalling activities. However, there are no guarantees that shorter timescales will produce more reliable data, and there is the potential that real, high stress incidents are ‘watered down’ by the repeated statements and reports of ambient temperature, on-station training exercises. Longitudinal work by Womack et al. (2000) followed 74 firefighters over a six-year period, and concluded that whilst firefighters had prolonged period of stress-free activity, there was often a sudden and intense energy demand during fire calls that has the potential for negative effects if the firefighter was not in adequate condition to meet the demands. Therefore, future data collection should not focus upon a time period, but instead consider the completion of questionnaires as soon as practicable once particular environments or incidents had been experienced.

One area not measured that may have furthered knowledge regarding the ability of firefighters to cope with early career demands was potential previous exposure of participants to related stressors in military, civil defence or other emergency settings. In a study of traumatic stress symptoms by Regehr et al. (2003), it was found that a sample of 65 newly recruited firefighters in the first week of training had an average of 3.19 years in some form of emergency service, including military service. Whilst exposure levels to multiple casualties, death of a child and witnessing violence against other were significantly lower than experienced firefighters in the study, they were as likely to have experienced violence against themselves and been in near-death experiences. The researchers suggest that 65% of new recruits entering the fire service as a career are exposed to many critical events before starting service. Given the similar findings found in police recruits, who were found to have high rates of trauma exposure prior to joining (Stephens et al., 1999), it may be the case that coping development may have occurred *prior* to entry into the service, and not *as a result of* situations or environments encountered due to fire service activities. Therefore, differing levels of distress and traumatic event exposure may not be attributable to on-the-job exposure alone. Pre or post study follow-up interviews may also be a potential avenue for further research to establish backgrounds of participants.

The frequency of the demanding tasks faced by the firefighters in this study was unknown, although there would have been no way of controlling for this. It is possible that a number of participants may have simply faced a task for the first time in their career, whereas for other participants it may have been a routine occurrence that they had faced that type of task many times previously in their career, or even during that week, or even that day. For example, during the firefighters' first month on station, six participants stated that they found a house fire persons reported tasks the most demanding situation they had attended during that timescale, whereas only one participant stated that their most demanding experience was wearing a gas-tight suit at an incident involving hazardous-materials (haz-mat). This may suggest that house fires are more demanding than haz-mat incidents for the majority of participants during their first month on station, or alternatively that haz-mat incidents are far more demanding than house-fires, but the six that did not state this to be the case had simply not experienced any incidents of this nature.

Finally, there was no account made of assessing gender differences, despite previous researchers stating that there is unequivocal support for the notion that men and women exhibit different coping behaviours (Nicholls et al., 2007). This is an issue described by the researchers to typically include males using more problem focused coping and females with more emotion focused coping (Anshel et al., 1998) and seeking social support (Campen & Roberts, 2001) in sport. In contrast, in a study of 749 athletes in a range of sports, Nicholls et al. (2007) demonstrated that were no gender differences between problem focused and emotion focused techniques, although certain problem focused strategies such as planning, communication and technique oriented coping were used more by females, and as such any gender differences may only be limited to one or two coping categories within each coping dimension.

4.4.5.3 Choice of coping measurement

Another methodological issue identified within this study was the ways in which firefighters coped with the demands placed upon them and how this process changed over time. This has been previously identified as a difficulty in the measurement of coping in the transactional stress model. This is the idea that coping strategies may change from one stage of a stressful encounter to another, making measurement and identification of trends or patterns difficult since coping usage is only specific to that individual environment or situation (Beaton et al., 1999).

The WOC scale required participants to identify the coping styles only used during the period they were experiencing the stressors during the task i.e. at the peak of physical exhaustion or mental degradation, not as a recovery method carried out hours or days after the incident. When administering the Ways of Coping Questionnaire (WOC) the period at which the participants were reporting their coping methods is unknown as to whether they were utilising a particular method for all or only during some of the scenario they had described.

Previous research by Stone et al. (1991) using the WOC found that one third of their subjects were thinking only of what they did during the acute stage of the task, 17% described coping during both acute and recovery stages, whilst 13% reported coping during the preparatory stage only, and the same amount during the recovery stage only. The researchers found that 56% of subjects did not base their coping reports on all of the problem stages that exist, although it is argued that different problems may not actually have all stages. For example, problems that cannot be anticipated may not have a preparatory stage, whilst problems resolved immediately may not have a recovery stage. An example of this is the identification of the 'tension reduction' that was considered by firefighters to be used on each occasion data was collected and consists of three statements: 'got away from it for a while; tried to rest or take a vacation'; 'tried to make myself feel better by eating, drinking, smoking, using drugs or medication'; and 'I jogged or exercised'. To deal with an operational fire situation it stands to reason that none of these methods would be possible during the acute stages of the incident when stressors are most profound. Similarly, the construct of 'problem focused coping' included the scoring of statements that included 'making a plan of action and following it' and 'know what has to be done and doubling my efforts to make things work'. These issues were to be expected, given that the original purpose of these scales was constructed to measure student populations undertaking examinations. It therefore seems apparent that in these instances firefighters were not applying the coping strategies to the acute phase only.

The WOC would therefore further benefit from changes to wording to make it more appropriate for firefighters. Anecdotal feedback from participants stated that a number of questions were worded in such a way to make the questionnaire feel more clinical (such as ‘I got professional help’) or not meaningful to firefighting (‘refused to believe that it had happened’) and as such they may not have felt comfortable answering such questions. This could have led to a potential lack of participation and subsequent reliability of the data gathered.

In response to similar issues, Dowdall-Thomae et al. (2008) have recently developed the ‘Revised Ways of Coping Checklist for Firefighters’ using the Revised Ways of Coping Checklist (Vitaliano et al., 1985), that included additional wording relating to the abilities of firefighters to transition from one fire and rescue incident to another. Unfortunately, at the time of this research taking place, this occupation-specific tool was unavailable, although the high reliability and similarity of the five coping categories measured by the WOC in this study (problem-focused, seeking social support, blamed self, wishful thinking, and avoidance) suggests that this inventory has the potential to be utilised within the population of UK career firefighters for future coping research. At present there is no further research that has utilised this inventory following its development, although this does provided a welcome and occupation specific measurement tool for coping.

4.4.5.4 Measuring coping

One of the limitations in the sport literature examining the effectiveness of coping strategies is that previous research has simply reported coping frequency as a measure of effectiveness, yet this does not necessarily mean that number of deployments made it more effective (Nicholls et al., 2007). In this study, a firefighter may have reported using four of the stated coping strategies a great deal and perceived themselves to have coped very effectively with the demands of the task, yet this does not inform as to *which* of the coping strategies led to this effectiveness, or if it was the unique contribution of methods deployed at different stages of the incident that contributed to success.

Different coping strategies and responses may have a differential impact upon outcomes, whereby an individual may use some strategies regularly but may have used a specific strategy once, such as an athlete in the final of a competition. As a result, use of measures such as Likert scales will not easily determine the balance between frequency and importance, and this method of collection limits knowledge development of coping (Richards, 2012).

Finally, there was no measure of perceived task importance, as recommended by Nicholls et al. (2006) for future stressor research in sport. For example, it is not clear whether there was greater importance placed upon passing the task that enabled them to pass their firefighter SCBA assessments at training school, or when attending a real-life incident where all persons were out or the building was already beyond saving, with situations considered as peak goal commitments by an individual likely to lead to increased stress in the individual (Lazarus, 1999).

4.4.6 Conceptualising Firefighter Performance

Athletes who cope more effectively to stressors have also been found to demonstrate increased performance standards during periods of stress (Haney & Long, 1995), and demonstrate greater emotional well-being during periods of intense stress (Lazarus, 1999a); however, this is not always the case in emergency workers and first responders. For example, LeBlanc et al. (2008) examined the relationship between coping styles and police recruits' stress responses and performance during a stressful event, using both biological and psychological indicators. The researchers found that whilst coping styles were associated with subjective and psychological distress, they were not linked to performance, and they suggested that police recruits appear to rely on their training and skill sets in stressful situations regardless of how they manage their emotions (LeBlanc et al., 2008).

When examining police recruits' subjective measures of stress immediately after a simulated stressful encounter, Regehr et al. (2008) found that increases in subjective anxiety were not associated with ratings of performance, suggesting that exposure to acute stress has no effect (either positive or negative) upon police recruit performance. Therefore, if faced with a stressor perceived as demanding, the results of these studies suggest that implementation of a first responder's coping strategy may not actually improve the short-term performance of the individual. The benefits of factors other than performance may be more apparent however, and this may be key in teaching and preparing firefighters to remain resilient and protect them from later psychological or physical disability. Dowdall-Thomae (2009) states that preventative measures such as the teaching of effective coping strategies for firefighters to use at the emergency scene may also reduce acute stress disorder in first responders by enabling optimum levels of functioning and performance. Dowdall-Thomae (2009) describes how although some firefighters appear to deal with on-scene stressors better than others, these stressors may become triggers for some firefighters during other incidents and may result in an increase in stress arousal that is capable of lowering levels of job performance. Based upon this, the coping strategies employed by the firefighters in this study have the potential to impact upon more than immediate performance (or satisfaction of performance), but upon future performance at incidents. Therefore, further research is recommended to examine the further benefits of coping skills in trainee firefighters, in particular the 'protection' that it may offer the firefighters from later psychological difficulties identified by Dowdall-Thomae (2009).

Coping progression and development within training exercises can often be considered to be appropriate when exposure to specific environments is not easily achievable. Given that competitive athletes have been estimated as spending up to 99% of their time in practice rather than competition (McCann, 1995), and firefighters spend at least a couple of hours of every shift training (Sommer & Nja, 2011), this training environment must be utilised effectively for stressor exposure and development of coping effectiveness. Just as serious athletes train physically for their sport, firefighters should train for the demands of their profession (Linville, 2011) and coping training must show progression to prepare firefighters to cope in stressful situations, considered to be the 'hallmark' of stress adaptation training (Meichenbaum, 1977). Richards (2012) suggests that there are numerous ways that coping progression can be increased and achieved, including manipulation of time urgency, increased task complexity, evaluation, frustration, and fatigue by exertion. One of the findings from the current study is the support that training environments encountered by participants allows for coping progression to take place. This was demonstrated by the increased number of stressors considered to be of a 'cognitive' and 'novel' environment when returning to training school at 12 months service in comparison to the first two SCBA tasks at the start of their career. The challenge will be in regularly changing the training tasks and situations to ensure that the coping progression recommended by Richards (2012) occurs, since the firefighters' experiences at operational incidents will continue to increase, and these tasks must also be designed to ensure that coping progression is increased in more experienced personnel.

4.4.7 Recommendations

Based upon the findings of this study, there is no prescriptive approach that can be provided to assist future trainee firefighters in coping during activities such as firefighting and SCBA tasks. It is unlikely that future trainee firefighters are likely to face, or perceive, the stressors in this study to be the same stressors during the first twelve months of their careers as the current population, or that the particular coping strategies identified in this study are considered to assist in reducing or managing such stressors. What the findings of this study can do however, is to educate future cohorts as to the possibility of experiencing such demands in early career and look at more ‘proactive coping’ ahead of more ‘reactive’ methods as early as possible.

Ng et al. (2006) state that there are a number of practical implications for perceived control, such as managers identifying their subordinates’ control beliefs inferred through daily interactions. It is suggested that even in the absence of feelings of control over their external environment thought to be consistent with decreased job performance, de-motivation or poor attendance, as well as negative work attitudes and behaviours, line managers can seek to promote positive attitudes by demonstrating the presence of indirect control (Ng et al., 2006). In these situations, cultivation of interpersonal relationships (including mentorship or group cohesiveness) can lead to employees with lower perceived levels of control believing that their colleagues around them have, and can help them, maintain high levels of control at work. Research has consistently identified the strong and often family-type closeness that exists in watches in the fire service (i.e. Thurnell-Read & Parker, 2008). Through the maintenance of firefighters (even with low perceived levels of control) being around their trusted colleagues, the benefits of high levels of perceived control can be found and utilised for optimising operational performance and well-being through increased perceptions of their self-worth at operational incidents.

Exposure to real incidents is of great benefit to firefighters, and this study has demonstrated that not all stressors and coping strategies can be learned through training environments. However, prior to this exposure it is recommended that persons engaged in extreme environments should experience the planning of ‘what if’ scenario’s relating to possible technical, physical, and psychological eventualities (Weston et al., 2009), and where the individual has insufficient experience or expertise they should enlist the assistance of elite performers to draw from their experiences (Weston, 2012). This advice could be considered applicable to new and inexperienced firefighters who are unlikely to have prior experience of ‘life or death’ situations, and when exposure to these ‘what if’ scenarios through training is unsafe or impractical.

4.4.8 Further research

Further research is recommended to examine the ways in which management of stressors and effective coping methods (in particular problem focused methods) can be embedded into the fire service by watch officers who deal with the firefighters on a daily basis and take charge of operation incidents by promoting social support on the fire station. With the majority of the methods identified in the Folkman and Lazarus (1985) WOC used in this study only being ‘used somewhat’, more coping methods should be considered and made available to firefighters to utilise during operational incidents. It is unknown if methods were reported as not being used because firefighters were simply unaware of how to implement such methods during the incident or knew but were not interested in their usage. Alternatively, firefighters may simply have been unable to effectively recall the strategy they used in an event three months earlier.

Further research is also required to identify the links between coping strategies and performance, as well as the relationship between outcome coping efficacy, mental toughness and optimal performance under stress. Again, an educational approach or toolkit establishing available methods should be considered once further research has established the most effective coping strategies.

4.5 Conclusion

To ensure the development of coping abilities of firefighters in early career, it is important that fire service training environments replicate the stressors and demands of operational incidents as it is not possible for the opposite to happen. This study suggests that there may be a number of differences between the stressors experienced by firefighters at difficult times. For example, this study identified that observation and assessment stress were only apparent when at training school and not during operational incidents, and that exposure to novel environments are encountered to a greater extent at operational incidents. Trainee and probationary firefighters demonstrate high levels of perceived coping effectiveness, control over the tasks encountered, and report high levels of performance satisfaction when exposed to tasks considered severe.

Further research is required to conceptualise what mental toughness is in firefighters, the acceptance of a suitable measurement tool, and exploration of its relationship to coping, coping effectiveness and self-efficacy of firefighters in early career. In line with descriptions and conceptualisation of this subject provided by Gordon and Gucciardi (2011), research should seek to ask why people are mentally tough and chose to adapt positively to stress and bounce back, not just how they do what they do, in order to explain when, why, and how these individuals can rise to the occasion and appear to thrive under pressure.

Despite the small sample and methodological limitations, the results were in line with previous athlete research and the Lazarus and Folkman transactional model of coping (1984). Recommendations such as the implementation of educational input at this career stage may be useful for early career firefighters although further research is recommended to examine the coping strategy for specific stressors, as well as the impact of SCBA stressors and coping strategy upon firefighter performance in both training and real-life environments.

Chapter 5

Physiological and psychological responses of novice and experienced firefighters undertaking firefighting and SCBA tasks

> “As firefighters, we must be prepared to meet the demands of the various types of emergency calls we might face. The very nature of our profession necessitates that we be physically and mentally prepared to meet these challenges. Consider yourself an ‘occupational athlete’.”
>
> Linville (2011, p.8)

Chapter 5 - Physiological and psychological responses of novice and experienced firefighters undertaking firefighting and SCBA tasks

5.1 Introduction

The UK guidance document for breathing apparatus wearing, Technical Bulletin 1/1997 (herein referred to as TB1/97), describes how often the work undertaken wearing SCBA will be complex, physically and psychologically demanding and in circumstances where the normal sensory perceptions are denied. Following the focus groups and individual interviews in chapter 3 identifying that the physical demands of firefighting and SCBA were considered to be the most stressful tasks undertaken when on duty, the next stage was to explore the ways of measuring specific reactivity to these scenarios by firefighters, and identify the specific SCBA tasks that create these physical and psychological demands.

Chapter 3 identified the three occasions where SCBA is likely to be worn during the firefighting tasks of the incident as being residential, commercial, and marine fires. Of these three, the most common location likely to be encountered by an on-duty firefighter was reported as being at residential dwellings such as flats, bungalows or houses. This is to be expected given that in 2007 the UK fire services had to attend to a total number of 52,700 dwelling fires in the UK, resulting in 331 civilian deaths and around 10,900 non-fatal civilian casualties (Operational Statistics Bulletin for England 2007/8; 2008). During the same period of 12 months, there were considerably fewer incidents in other structures, with 31,000 fires in buildings classified as ‘other than dwellings’ resulting in 36 fatalities and 1,300 injuries to civilians.

Each of these dwelling incidents are likely to present a risk of injury to the firefighters responding to these incidents, with US statistics from the National Fire Incident Reporting System reporting that 87 percent of all firefighter fire-related injuries occur in structural fires (2011). As a result, any research further investigating the situational specific demands of tasks likely to be encountered whilst firefighters are wearing SCBA and their abilities to carry out consistent operational response is of importance to the firefighters, persons in need of rescue and incident commanders who commit the wearers to the scene of operations.

5.1.1 Prolonged and repeated SCBA wearing

During a shift a firefighter may respond to a high number of fires that require the use of SCBA, and these may vary considerably in terms of frequency and duration. For example, firefighters may be required to wear SCBA at consecutive incidents with no rest period, independent incidents with a brief rest back at the fire station, at independent incidents where SCBA activities are undertaken after fire suppression activities, or they may wear SCBA more than once at the same incident. Despite this, at present in the UK there are no set guidelines or procedures in place that advise the number of times that firefighters can wear SCBA when responding to operational incidents or the rest periods required during or after wearing. Instead, decisions regarding crew welfare are left to the supervisory managers (who will act as the incident commanders when deployed to an incident) on the watch to make an informed call based on specific individuals. This may include decisions regarding task allocation and cooling strategies at an incident, the number of SCBA wearers to commit at further incidents, and the urgency and importance of the requirements for these skills at the incident.

Whilst a growing body of research has focused upon SCBA effects by incorporating research protocols using either laboratory based equipment or purpose built training structures (i.e. Del Sal et al., 2009), the majority of studies have done so utilising a single SCBA wear. To date, only a limited number of studies have attempted to address the issue of operational redeployment or multiple breathing apparatus wears during the same time period either in training or real work. In a study looking at the effects of these prolonged periods of physical exertion on cardiac function, Fernhall et al. (2012) found that three hours of intermittent firefighting activities produced alterations in left ventricular function consistent with ‘cardiac fatigue’ (decreased systolic and diastolic function) previously found in endurance athletes such as marathon or triathlon competitors. Maximal heart rate, as measured by the formula 220-age (Astrand & Rodahl, 1986) presented each of the five times that participants were actively taking part in fire suppression activities, which also resulted in dehydration and hyperthermia throughout testing.

In terms of repeated and concurrent SCBA tasks, research for the Office of the Deputy Prime Minister (ODPM) by Elgin and Tipton (2003) has shown that firefighter instructors are capable of successfully carrying out a rescue task immediately following a 10-minute hot-fire training task, but concluded that due to the closeness to their physiological limits, in more severe situations or environments a rescue may not be possible. More recent research conducted by Carter et al. (2008) has also explored this area of concurrent redeployment by measuring the effects of an initial search and rescue task followed by either 30 minutes or 120 minutes of rest in one of three recovery sites before undertaking a repeat of the same task, but undertaken on a different floor to ensure they were not familiar with the route. According to Carter et al. (2008), it is estimated that on average, under live fire conditions after an initial deployment of 26 minutes, 50 minutes of recovery would be required to safely perform a further redeployment of 24 minutes. This suggests that issues of redeployment and repeated SCBA wearing may pose a hazard for the firefighter at an incident if insufficient rest periods are available between SCBA wears.

5.1.2 Methodological difficulties in the measurement of SCBA

The performance of firefighters in response to physiological and psychological demands has previously been measured through data collected in three environments: laboratory based research, training environments, and real life measurement both en-route and on the scene of incidents:

5.1.2.1 Laboratory based studies

A number of researchers examining the demands of firefighting have preferred to use laboratory based activities to collect SCBA data. This methodology has included tasks such as treadmill walking tasks whilst wearing firefighting personal protective and respiratory equipment (Gravelling et al., 1999), whilst there are also examples of researchers attempting to utilise physical activities such as static cycling or treadmill walking alongside completing computer-based fire tasks. For example, research by Webb et al. (2011) assigned firefighters to either a control condition (exercise alone) or a condition consisting of undertaking an exercise considered to be representative of a fire suppression activity (in this study a cycle ergometer at 60% VO2 max for 37 minutes) while participating in a computerised ‘Fire Strategies and Tactics Drill’ (FSTD) based upon their knowledge of incident command and fireground operations.

Although affording close control and measurement of variables, the laboratory setting cannot be considered representative of the firefighting environment in a number of ways, in particular the lack of any realistic conditions that include heat, humidity, auditory and visual degradations, and nature of the task. Lieberman et al. (2006) state that the main limitation of the laboratory environment in military research, similar to firefighting, is that whilst it can induce a number of stressors likely to be found in the field by soldiers, disaster victims, first responders and command authorities (including sleep loss, inadequate nutrition, environmental extremes and requirements to rapidly complete demanding physical and cognitive tasks), the stressors present in the real world including fear of death and injury, confusion, and uncertainty often exceed any lab-based stressors.

5.1.2.2 Training environments

Due to the lack of control in the monitoring and regulation of environmental conditions during real-life incidents it is difficult to gather suitable physiological data, and as such the majority of firefighter research has utilised data collected during simulated firefighting activities in training facilities that recreate 'hot' or 'live' fire conditions, or recreate fire conditions using cold, artificial smoke.

Advances in data collection methods have led to increased usage of variables in fire service training structures that were only previously accessible in purpose built physiology laboratories. For example, research by Williams-Bell et al. (2010) has utilised systems that measure directly from the SCBA set and remove the need for SCBA air management that previously involved gas collected in bags for later analysis (Lemon & Hermiston, 1977), and are now able to measure a variety of outputs including air consumption, oxygen uptake, carbon dioxide output and respiratory exchange ratio. The result is that the data is now able to be gathered data outside of the laboratory yet still allow for the increased standardisation and repetition of variables such as temperature and task in a more realistic environment.

It is important not to underestimate the intensity of a training environment, and it is not uncommon for training conditions of up to 300^{o} C to be used for a pre-determined time period, which is often greater than expected at actual incidents, and presents a real risk of injury for personnel (Gravelling et al., 2001). Research by Love et al. (1996) suggests that excessive physiological strain is likely to be experienced by firefighters during SCBA exercises, with effects including very high heart rates, body temperatures of over 40^{o} C, and sweat loss averaging the equivalent of 2.5 litres per hour.

However, even this replication of real life incidents in a simulated environment can be problematic. For example, Webb et al. (2011) suggest that the unique properties of fire suppression tasks undertaken at real life incidents often make it difficult to conduct research in this area. Due to the safety and standardisation considerations in real-life incidents, controlled training exercises often result in firefighters simply performing routine training exercises. Webb et al. (2011) suggest that the studies that have collected data in controlled training environments often fail to quantify workload, making it difficult to establish if any effects measured are due to the physiological intensity of the task or the combination of physiological and psychological stressors. Whilst simulated environments are often utilised to replicate the effects of real life stressors, their usefulness is limited due to not being able to match the intensity of actual firefighting. Often the greatest demands of the training environment are not the ability to perform under simulated conditions but the pressure and stress of being assessed and observed by senior officers and training staff typically present during such activities (as demonstrated in chapter four), which creates an inconsistency relative to real life incidents where this would not be present.

5.1.2.3 Real life measurement

To ensure validity and aid the benefits of any findings, ideally all research and measurement of breathing apparatus tasks would take place in the real world, with Sommer and Nja (2011) stating that a considerable part of firefighters' experience is acquired from responses to real incidents. As well as the increased realism and validity of real world measurement, previous research also suggests that the lessons learned from real incidents are typically seen as more valuable by firefighters than those from training environments that are considered to be limited by the artificially and constrained objectives of a simulated training task (Crighton et al., 2008).

However, any potential gains in understanding at real-life events are offset by methodological issues, in particular owing to novel environments faced by firefighters providing a difficult task for researchers in controlling variables, or being able to generalise any data gathered. The environments faced and the limited space on the fire engine would mean that any attempts by the researcher to be on-site to measure any variables would prove problematic en-route, and potentially hazardous to the health and safety of the researcher whilst on the scene. Finally, any data collection equipment or apparatus utilised must not have any impact on the response time of the firefighters, given the potential delay of only a few seconds could have upon the welfare of those in need of rescue or to the structural integrity of the building on fire.

Despite these limitations there are several occasions where researchers have tried to collect data at operational incidents, such as the duty effects of firefighting tasks conducted by Barnard and Duncan (1975) which examined heart rate and electrocardiogram (ECG) recordings, and was one of the first studies to document that heart rates become elevated in firefighters even prior to reaching the fire. The researchers found a mean increase of 47 beats per minute in response to an alarm and remained elevated en route. While this initial study provided limited data, it did document the increased heart rates that are experienced during fire suppression, with one subject recording a heart rate greater than 188 beats per minute for a 15-minute period on the scene. Regarding the ECG data, whilst subtle changes in the ECG results of firefighters en route to the fire were found, it was not possible to successfully monitor ECG data during firefighting activities due to excessive movement of the firefighters.

Other researchers, such as Kuorinka and Korhonen (1981) have monitored heart rate responses at actual emergencies and found that there was a sharp increase in heart rate after responding to an alarm, before it reduced slightly whilst travelling to the fire, although it still remained elevated compared to pre turnout values. However, it is unknown if these increases can be attributed to high environmental temperatures or wearing PPE, or if they are instead more likely the result of increases in physical activity or psychological stress. Barr et al. (2010) states that there is a need for caution when using heart rate as a measurement during real life incidents, as the exact and relative contributions of the cardiovascular, nervous and thermoregulatory system are difficult to determine. At present, further study is required to establish the specific and typical responses that firefighters may expect to face at an incident. Only once these effects have been established can assumptions begin to be made as to the relationship between any physiological and psychological effects observed during training and real life incidents.

5.1.3 SCBA environments

It is likely that during dwelling fires, firefighters will be exposed to a wide range of temperatures, each with their own unique difficulties and wide ranges of environmental conditions inside the structure. However, during SCBA tasks in training environments, these internal temperatures can be broadly categorised as being either an extreme / acute heat, or a temperature representative of the current outside temperature.

Acute heat is achieved through the use of ‘live’ (burning) fires that produce more radiated light and visibility from the fire but at a cost of high temperatures and resulting risks of heat stress and dehydration to the firefighter, as well as the weight of carrying charged lengths of hose through buildings and up / down internal or external staircases. Furthermore, work capacity in high temperatures has previously been found to be significantly reduced compared to work capacity in cooler conditions (Galloway & Maughan, 1997). Using an overhauling task at either ambient conditions with no fire (around 59°F) or live fires (around 195°F) Smith et al. (1997) found the heart rates of their firefighter sample to increase an average of 36 beats per minute in live fire conditions, suggesting an increased physical demand that may be directly attributable to increased temperatures during the task.

Temperatures more representative of the outside surrounding temperature may be encountered following the extinguishment of a fire at an incident, and may include heavy smoke logging inside the premises. Although lower in temperature, tasks in these temperatures involve far more limited visibility since there is no radiated light from the fire, and this will increase potential dangers of fire damaged locations such as stair cases and flooring burnt away by the fire. The ability to work under reduced visibility is a key ability of firefighters, with previous research by Mora (2003), identifying that in all incidents there was prolonged zero visibility (typically heavy smoke conditions lasting longer than 15 minutes), and that this smoke logging led to firefighter disorientation (and death) inside the structure. As such, firefighters must be proficient and confident during both types of conditions, both for their own well-being and those around them including casualties and other firefighters.

Whilst there are an almost infinite number of environment and condition interactions that firefighters will be expected to face on a daily basis, their type of search technique can be broken down into three main types (Young, 2007):

- Free search
- Using a guideline to locate a casualty
- Firefighting

Descriptions of each are provided below, with descriptions adapted from TB1/97:

5.1.3.1 Free search

One of the standard protocols used in the UK to search a room is to either ‘sweep’ left or right depending upon the instructions of the incident commander. On a ‘left hand’ search / sweep the breathing apparatus team leader maintains contact with their left hand against the left hand side bulkhead, with the other hand used as to manage the hose or provide self-protection from any overhead or immediate hazards in front. Other team members can either maintain contact with the team leader and each other through physical contact with that person or by clipping their 1.25 metre, short ‘personal line’ (which is a fixed piece of apparatus on the waist strap of the BA set) onto a designated ring on the team leaders SCBA set via a karabiner.

Although the full length of a personal line is 6m, the line pays out in two separate lengths, a short length of 1.25m, and upon releasing the clip, the full 6m length of the line. The premise is simple; the SCBA team leader never loses contact with the left bulkhead whilst other team members maintain contact and search off the team leader to search a designated space. Upon finding a casualty or any time requiring exit, the team leader simply places their opposite hand on the bulkhead (essentially turning 180 degrees around) and retraces their footsteps to their point of entry as demonstrated in figure 5.1.

5.1.3.2 Guidelines

Whilst the left (or right) hand search method provides a standardised method of quickly searching premises and ensuring SCBA teams maintain contact with each other, this method is not effective in environments where no other practical or appropriate means are available for tracing the way out of a risk area. This may involve large structures (such as large factory units) or environments with a complex layout and limited means of access and egress (such as marine vessels), searching in thick smoke, where premises are flooded, or where high expansion foam has been used. Consisting of a 60 metre line contained in its own bag, the guideline can be considered a special line which is used to indicate a route between an entry control point and the scene of operations, allow SCBA wearers to retrace their steps to the entry point in a risk area, and allow subsequent teams to locate other SCBA wearers and the scene of operations. The exit route of a guideline is identifiable by its touch, with two ‘tabs’ 150mm apart fitted at 2.5m intervals along the length of the line and a knotted tab of 50mm to indicate the way out. Due to the risk of fire penetrating the line, guidelines would not be used in the same location as an on-going fire but rather during post fire conditions including heavy smoke logging, although such post-fire conditions would not immediately suggest the absence of intense heat.

Typically a SCBA team will be deployed to lay the guideline, tying off the line to suitable points in the structure (such as door handles or internal piping); with subsequent SCBA teams deployed to search off the pre-laid guideline. When a SCBA guideline search team is utilising a guideline, upon reaching a tie-off point, the team leader will simply unclip and re-clip their karabiner onto the guideline. Whenever a guideline has been laid, an SCBA search team leader must be attached to the line by the personal line on their SCBA set, with subsequent team members attached to the team leader and each other by their personal line. Unlike with free search techniques, SCBA team leaders are permitted to use their 6m personal line with team members coming back inside on their 1.25m line. An example is provided in figure 5.1. Whilst allowing for a greater area to be covered, the potential exists for entanglement of team members, and as such, a more methodical search approach is often required.

Often used alongside guidelines are ‘branch’ guidelines, a further 60- metre line in its own bag that is attached to the main guideline when the distance of the search area from the main guideline is greater than the length of one personal line. This may include a large structure such as a supermarket where there are a number of aisles or corridors that must be searched. Unlike guidelines, that are identifiable by a tally marked either ‘A’ or ‘B’ at the entry control point, a branch guideline is identified by a plastic tally at its starting point on the guideline with a designated number of holes drilled through (i.e. 1 hole for the number one tally). Again, designated teams will be allocated at the scene by the incident commander to either ‘lay’ or ‘search off’ a branch guideline, although all firefighters who wear SCBA are often trained to do both.

Guideline and branch guideline tasks can be considered to involve a higher degree of fine motor skills and concentration both from the team leader who is required to find suitable tie-off points and the team member following who is required to tie off the guideline using suitable knots whilst wearing thick fire gloves, in darkness and whilst wearing breathing apparatus. Even when following a pre-laid guideline to the scene of operations this creates potential hazardous situations due to the likelihood of entanglement of 1.25m personal lines with the guideline and of team members' personal lines with each other.

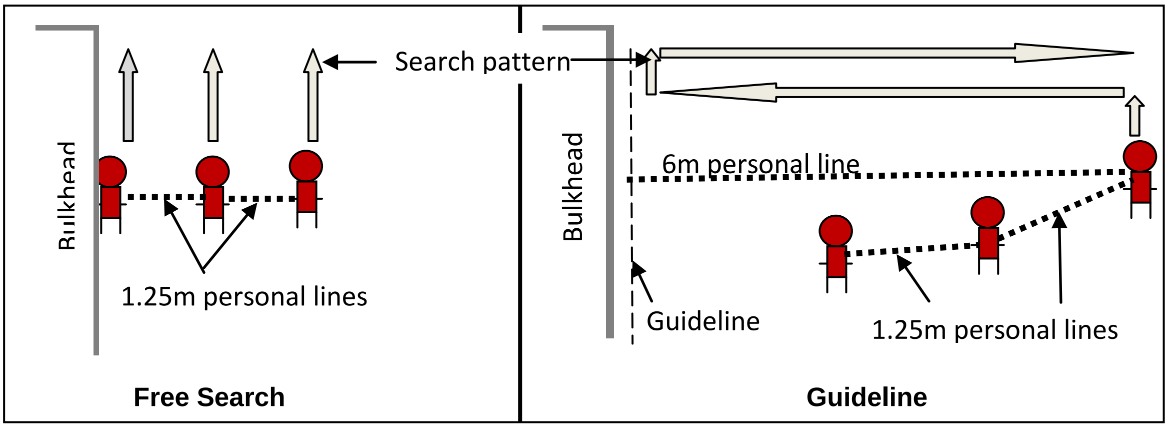

Figure 5.1. Search techniques and search patterns of free search and guideline exercises

Because guidelines are typically used in larger structures with complex layouts or limited access and egress, there is an increased risk to the firefighter if they encounter any difficulties when inside the structure. In 1991, two firefighters lost their lives when attending a fire at a large record storage facility at Gillender Street in London after laying a guideline. Upon attempting to make their way out of the five storey structure, and suffering from the effects of severe heat and exhaustion, the four-person SCBA team was following the guideline back to safety when they came across a branch guideline that had been tied by a following SCBA crew. Disorientated, they then incorrectly followed this branch guideline only to find they had retraced their steps to the fire compartment. Following a disagreement as to the correct way to make their way out, the team split into two teams of two. Two of the firefighters just made it out (the team leader had run out of air and was struggling to breathe when reaching the exit), and two died inside the building after running out of air. The management report produced by London Fire Brigade after the 1991 Gillender Street fire cited by the Fire Brigades Union in their 2008 report states that it is important that operational personnel have their judgment and behaviour tested in a controlled training environment, to ensure that firefighters are able to deal with operational incidents in a confident manner when they arise.

A review of the literature has identified only one published study exploring the demands of guideline exercises. In a report produced for the London Fire Brigade, Brewer et al. (1999) utilised 69 firefighters undertaking eight tasks, and demonstrated that a guideline task of 20 minute duration led to a mean maximum heart rate of 145 beats per minute in participants, although psychological responses were not measured. Unfortunately, the simulations used are not described in detail in the report of Brewer (1999), making a detailed review of the results impossible to apply to other SCBA studies identifying the physiological or psychological demands of incidents involving guidelines.

5.1.3.3 Live firefighting

As the name suggests, one of the essential components of a firefighter's operational response is the ability to locate and extinguish a fire. This is often achieved when inside the affected structure through aggressive searching and water management strategies, under extreme time pressures to reduce the risk to potential casualties, and to prevent further fire spread causing damage to both the property and others not yet affected by the fire. Whilst occurrence of fires can exist in almost all locations at an operational incident, the training environment is able to replicate the thermal conditions by lighting large quantities of combustible materials in a self-contained crib inside a SCBA training structure.

Live fire based SCBA training is important for not only teaching firefighters correct techniques and procedures, but also allows firefighters to gain experience of working in adverse thermal conditions. Previous research using questionnaires sent to all UK FRS's by Gravelling (2001) has identified that in the UK, 95% of FRS's provide fire or flame training, with 96% providing heat training and 65% using heat and humidity training. As a result, maintenance of competency and ability to perform to a high standard under live fire on a frequent basis under realistic conditions are accessible to most firefighters in the UK.

The live fire training structure is likely to consist of fire-proof materials allowing for repeated usage for firefighters without the risk of structural collapse but still creating extreme conditions that include heat and severe smoke production that must be managed by crews (Gravelling 2001). Unlike in a free search or guideline scenario however, when undertaking live firefighting scenarios there is often a high degree of light emitted from the fire that reduces the need for a ‘free search’ pattern. Additionally, as charged hoses are required to extinguish the fire that are attached to the fire engine pump, the firefighter has a rapid and ready-made means of egress from the fire to a safe environment (by following pre-laid hoses). As a result, live firefighting tasks are typically fast, intense and have a higher risk of injury to the firefighter due to the proximity and potential spread heat and fire that will not be present in tasks utilising obscuration masks or smoke generators.

5.1.4 Aims of chapter 5

This study was split into two main sections: an exploration of the pre and post task differences in psychological and physiological parameters between novice and experienced firefighters undertaking live firefighting tasks (phase 1); and a comprehensive study of the demands of specific breathing apparatus tasks performed under ambient and live fire conditions (phase 2). As a result there were a number of broad aims to chapter 5:

Phase one:

i. Examine the physiological demands of live firefighting in novice and experienced firefighters.
ii. Determine the self-reported effects of live fire upon mood states in novice and experienced firefighters.

Phase two:

i. Examine the effects of three repeated breathing apparatus tasks in experienced firefighters: search and rescue; guidelines; and live firefighting.
ii. Consider the physiological demands responses to each of these three SCBA tasks, including heart rate, blood pressure and air consumption.
iii. Examine the pre-post task changes in mood following each of the SCBA tasks and look at any differences and similarities between tasks.
iv. Determine situation specific demands of each task in terms of self-rated workload facets.

It was expected that in phase one, following exposure to live fire or ambient temperatures through undertaking firefighting tasks whilst wearing SCBA, heart rate and blood pressure would significantly increase post task suggesting the presence of an extremely high level of physical demand. These effects were expected to be greater in novice firefighter compared to experienced firefighters undertaking the same task. It was also expected that levels of alertness would significantly decrease immediately post firefighting task, again with greatest effects demonstrated in novice firefighters.

In phase two, there was predicted to be task-specific psychological demands to each of three common SCBA tasks stated above, with live fire the most physically demanding, and a guideline task was expected to produce the most frustration despite lower physical effort expected to be required. Mood measures of alertness were expected to rise post task, whilst calmness was predicted to decline following completion of each of the three exercises.

5.2 Methods

5.2.1 Participants

There were two separate groups used in this study: novice and experienced firefighters, both of which consisted of full-time firefighters from the same urban, metropolitan fire and rescue service. The novice cohort consisted of seven trainee firefighters, five of whom were male and two were female, with an age range from 18.1 - 29.6 years of age (mean 24.3 years). All participants were in the ninth week of a course in initial firefighter training, a compulsory 13-week training course which was the prerequisite training to work as a full time firefighter. All participants had previously undertaken a two week SCBA training course in ambient conditions which they had successfully passed, and were all considered fit to undertake live firefighting tasks by a fire service occupational physician. Unlike in previous studies (i.e. Regehr et al., 2003), participants did not have any previous emergency services experience. The novice cohort only took part in phase one of data collection.

The experienced firefighter cohort were characterised by having passed an initial firefighter training course and were currently all working at an operational fire station. In addition, all participants considered to be experienced had all successfully passed their probationary period. Twelve experienced males were recruited, with ages ranging from 28.0 to 50.0 years of age (mean age 39.7 years). Mean length of service was 14.7 years although years of operational service ranged from 2.1 to 28.1 years. Eight of the participants were firefighters (FF), three were crew managers (CM) and one individual was a watch manager (WMB) and all were career / full-time fire and rescue personnel from two separate fire stations. The experienced group took part in both phase one and phase two data collection tasks.

The experienced participants were selected at random utilising a scheduled breathing apparatus refresher training that was due to take place in the specialist live fire structures. All participants were competent SCBA wearers who had all passed bi-annual SCBA assessments, and were considered currently fit for active duty by a fire service occupational physician. This bi-annual assessment included passing guideline, search and rescue, and live firefighting exercises, which is not currently required by trainee firefighters. All of the experienced personnel had all experienced live fire conditions in both training and real life incidents. All of the firefighters, crew managers and watch managers in this study were required to wear breathing apparatus at least once in a bi-monthly period either at training or at an incident, and demonstrate the application of key elements of SCBA (such as emergency air supply equipment and entry control procedures) at least once every three months. In addition, every two years all firefighters within this fire and rescue service received fire behaviour training and undertook a SCBA operational refresher course involving theoretical input and formal practical assessment in SCBA at their purpose built training school.

Participants in both phases of the study were given a participant number that was randomly allocated to them by the researcher with the Prefix FF followed by their allocated number (for example FF2). Unlike in chapter 3, this number did provide any additional information about the years of operational experience of the participant.

In line with the health and safety guidelines for working in live fire conditions, exclusion criteria for this study were strict and dictated by senior training officers. For the novice firefighters, despite informed consent forms being signed prior to taking part in the task, training officers were given the right to veto any involvement by the participant on health and safety grounds if they perceived them to be unable to meet the demands the task would place upon the individual. Exclusion criteria for experienced participants included any type of pre-existing injury, recent viral illness, and previous failure to meet required training standards during SCBA tasks undertaken in ambient temperatures.

5.2.2 Apparatus

5.2.2.1 Breathing Apparatus Training Structure

Both phases of the study took part at a purpose built Breathing Apparatus Training Centre (BATC). During phase one, one live firefighting task was undertaken, and during phase two, two further tasks were involved (search and rescue, and guidelines). Tasks took place inside a purpose built three storey fire training structure (figure 5.2) featuring different points of entry to prevent any familiarity. Internal walls inside the structure were also moved to ensure the task represented a novel environment, and realistic sound effects were played through the building via internal speakers to replicate noises and enable the presence of hearing degradation considered to replicate those encountered at real incidents.

During live fire conditions firesets were lit on the ground floor around one hour prior to subjects beginning their live fire training to provide a preheated and relatively stable temperature of 180-200^{o} Celsius as measured by internal thermocouples. Throughout the burn, experienced stokers and fireground technicians monitored conditions at a number of points in the structure and added materials to increase the heat or ventilate the roof to decrease heat. Scenarios under ambient temperatures involved the use of obscuration masks over the breathing apparatus mask to simulate heavy smoke filled conditions inside the structure.

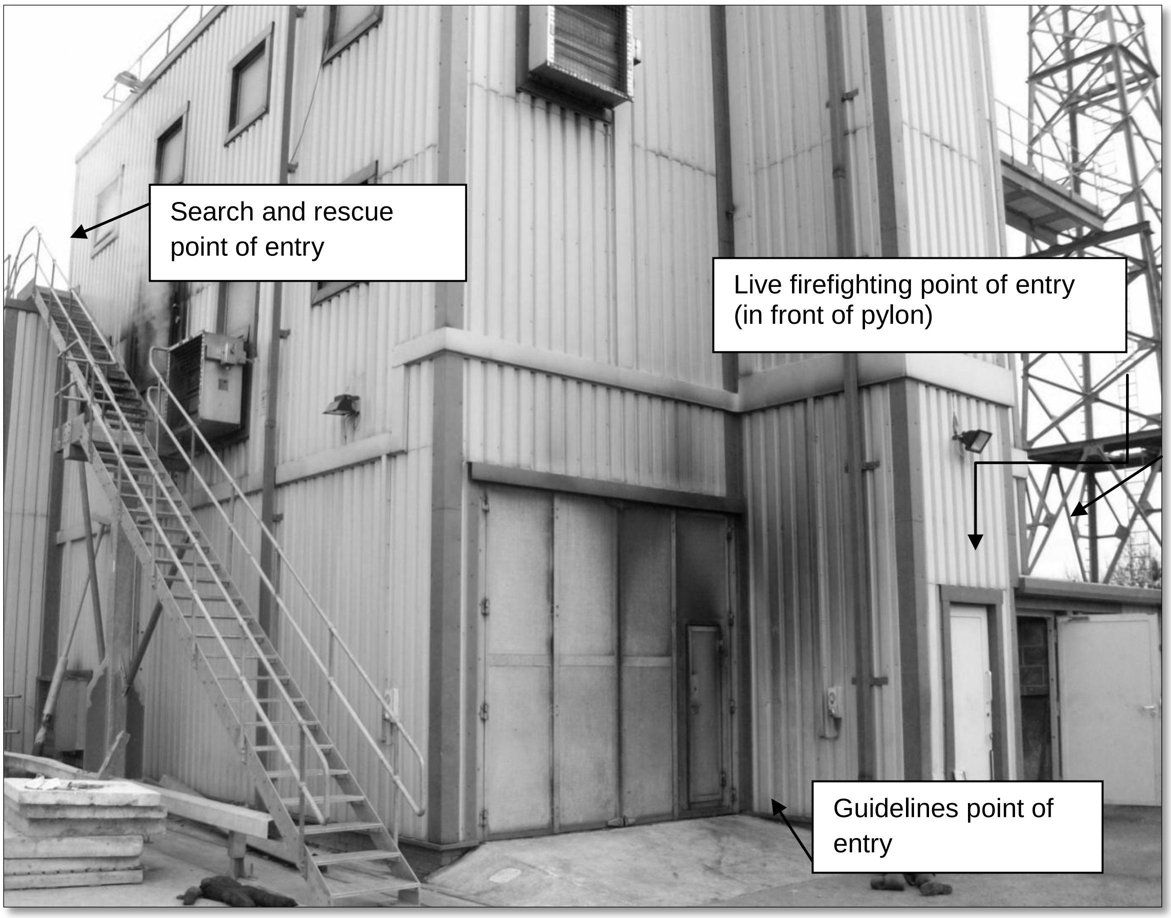

Figure 5.2. Large breathing apparatus structure and points of entry for each of the tasks

5.2.2.2 Personal protective equipment (PPE) and self-contained breathing apparatus (SCBA)

During each of the scenarios, all firefighters were dressed in fire service uniform of trousers and polo shirt. PPE included personal issue fire tunic, overtrousers, fire boots, fire gloves and helmet, and also included the use of a flash hood to protect the neck and ears.

Phase one participants were issued with the then current Interspiro QS breathing apparatus set, a two stage, self-contained open circuit compressed air device (Interspiro Ltd., UK). An air cylinder containing 1800 litres of air and a working pressure of 300 bars allows for duration of use of up to 45 minutes. In addition, the BA set featured a Bourbon type pressure operated cylinder contents gauge that allowed the wearer to identify the air pressure left in the BA set and which had a built in warning whistle that actuated once the air pressure dropped between 55-60 bars as a standard safety feature.

Phase two participants used the current Draeger PSS 7000 breathing apparatus set (Draeger, UK), including the use of a 300 bar cylinder providing up to 49 minutes of compressed air. One of the key components of this Draeger BA set not found on the Interspiro SCBA set was the Bodyguard 7000 pressure gauge attached to the SCBA set, which is a pressure activated electronic system that provides continuous monitoring of personal wearer information. This gauge allowed the wearer to accurately see the current air pressure in the BA set via numerical display, as well as the minutes of air left in the cylinder. Additional safety measures include a movement operated and self-deployed audible and flashing alarm that activates on the breathing apparatus set (known as an automated distress signal unit or ADSU), which also electronically alerts an entry control officer based outside the structure to a breathing apparatus wearer in distress.

5.2.2.3 Psychological measures

Perceived workload

The National Aeronautics and Space Administration Task-Load index (NASA-TLX) (Hart & Staveland, 1988) was incorporated in phase two to measure the participants' perceived workload of each SCBA exercise completed. This scale has been reported as having high internal consistency with a Chronbach's alpha of more than 0.80 (Xiao et al., 2005). Consisting of six workload facets (mental demand, physical demand, temporal demand, effort, performance and frustration) participants were required to state their subjective experience of the task they had just completed along a visual analogue scale labeled from 'low' to 'high'. The measurement scale was from 0-100, with a higher score indicating greater effort for that facet.

Mood State

In order to assess stressor-induced changes in mood, the Bond-Lader Inventory (Bond & Lader, 1974) was incorporated before and after the completion of each breathing apparatus task for both phases of the study. The Inventory consists of 100 mm visual analogue scale anchored with antonyms and combined to produce mood factors of alertness, calmness, and contentedness, with each of the scales showing high internal validity (Chronbach's alphas = 0.77 - 0.93) (Bond & Lader, 1974). Each line is scored as millimetres to the mark from the negative antonym, with each factor capable of a maximum of 100 mm.

5.2.2.4 Physiological measurement

Heart rate and blood pressure

Heart rate and blood pressure measurements for both phases of the study were taken using the same device through an upper arm inflatable cuff operation (Omron M2, Omron Worldwide, UK). During blood pressure measurement, systolic blood pressure (SBP) represents the strain placed against the arterial walls during ventricular contraction, whilst diastolic blood pressure (DBP) relates to the peripheral resistance, or ease by which blood flows into the capillaries (Hoffman, 2006).

Perceived Exertion

Ratings of perceived exertion (RPE) were measured in both stages of the study using a 15 point version of the Borg Scale (Borg, 1970), which has been found to have HR and work intensity correlation coefficients between 0.80 and 0.90 (Borg, 1982). Completed immediately post task, participants were required to state self-perceived ratings by stating the number that most closely applied to them between 6 (20% ‘light effort’) and 20 (‘exhaustion’).

Air usage

Air usage of the BA wearers was collected through the use of a Draeger Merlin Telemetry Board (Draeger, UK). The SCBA wearer removed a plastic tally with their identification details on from the SCBA set and placed it into a dedicated board (an entry control board) outside the structure. This allowed the entry control board to wirelessly ‘read’ the information of the wearers SCBA set, including a live feed of air left in the cylinder as measured by bars pressure, time until the 10 minute low pressure warning whistle sounded, and the time until all air in the cylinder was exhausted.

As a backup, a dedicated entry control officer (ECO) monitors this board and uses manual calculations to determine the air available in each of the SCBA wearer’s tanks and the time they should be exiting the building. The ECO also annotates on the board the time of entry and time of exit for each SCBA team member. This was further supported by the use of communications between the wearers and ECO on a dedicated and pre-determined radio channel via a personal handled radio. Air usage was taken at the participants point of entry and upon immediate exit, and was taken to include bars of pressure used.

5.2.3 Procedure

Initial approval was obtained from the Northumbria University School of Life Sciences ethics committee, whilst fire and rescue service approval was also obtained from the training school manager, and senior learning and development manager.

In order to gather novice participants, the then current trainee class was spoken to as a group by the lead researcher while they were at training school detailing the nature of the study, and provided with an ‘information for participants’ booklet. They were informed that the study would be taking place alongside their SCBA training exercises and that if they would like to take part they were to e-mail the lead researcher within the next 14 days.

For experienced personnel, a letter was sent to the station managers of the fire stations about to undertake SCBA refresher training detailing the nature of the study and requesting voluntary participants as well as providing a detailed ‘information for participants’ booklet. The station manager then informed the four watch managers within the station of the study, provided copies of the booklet, and asked for them to request volunteers from their watch. The watch manager would then provide the station manager with a list of interested parties to inform the lead researcher. Participants were informed that the aim of the study was to examine the impact of their forthcoming SCBA training and that any methods would be non-invasive.

Prior to involvement in the study all participants were provided with and read a signed an informed consent form provided by post after a cooling off period of 14 days after indicating an interest in taking part and approved by Northumbria University’s board of ethics. This form was returned to the lead researcher via pre-post envelope. Informed consent was provided away from the course instructors at the training school to prevent peer pressure to participate.

One of the key elements of study participation was that since all participants would be providing physiological and psychological measurements pre and post SCBA exercise, their participation in the study would be known to other personnel in attendance and also to the training instructors. However, they were informed that any data provided would be confidential and that they would only be identified in any published results as a participant number. In addition, training school instructors were made aware that a study was being undertaken and what the investigative aims of the researcher team were and that individual data would not be provided to them at any time. Although the lead researcher for this project was also an employee of the same fire and rescue service as the participants, he had no direct contact with them during the course of a normal work routine, and therefore there was no additional pressure upon the participants to take part.

All testing of participants and each aspect of the two phases took place in the BA set servicing room at the fire and rescue service's Breathing Apparatus Training Centre (BATC), part of a larger on-site purpose built firefighter Training Centre (BTC). Upon arrival, participants were greeted, given an overview of the procedures to be followed and asked to read and sign an informed consent form, and after having read and agreed that they had understood the 'information for participants' booklet. At this point participants were given the opportunity to ask any questions and were also given an explanation of the information they would gain as a result of their participation in the study. A copy of the booklet used for data collection is provided in appendix F.

5.2.3.1 Phase one

All participants taking part in phase one were given time to service their breathing apparatus sets, which took approximately 10 minutes, and given time to change into their personal protective clothing. Although the novice and experienced personnel completed the live firefighting task at different times, the task undertaken and the temperature within the structure were both standardised, and followed the exercise brief developed by the BATC for live firefighting training.

The participants were split into two teams selected randomly by their course instructors, made up of teams of two, three, or four participants, and given a briefing on the task: a report of a large commercial factory unit on fire, with people reported inside. Standard Operating Procedures (SOP) were adhered to and safety officers also wearing SCBA were to be in attendance at all times.

In order to measure their response to an initial response to a fire call, all participants then completed the Bond Lader mood scales, and had their heart rate and blood pressure taken by the researchers. Participants allocated to go first by the training instructors were then required to immediately don their SCBA sets, start up their air supply and enter the building with an experienced instructor who was there to act as a safety officer but not to offer any help or advice on the task. The remaining participants were required to don their SCBA sets and enter the building to undertake the same exercise immediately once the first team had exited.

The task was the same for both teams. The brief was to enter the property (set up as two-storey residential premises) on the ground floor through a double door, locate the seat of the fire, extinguish the fire, and rescue any persons inside the building (in this scenario a single 90kg dummy). To ensure consistency, the dummy was placed back in the exact same location by the SCBA instructors within the structure before the entry of the next team.

Following withdrawal from the live fire structure, which could either be done by completion of the pre-determined task (casualty rescue and / or fire extinguishment), or by indicating to the safety officer they were unable to continue, participants were asked to verbally report their highest perceived rate of exertion (RPE) during the task using the Borg Scale (Borg, 1970). Participants would then complete the Bond-Lader mood scale before the researcher would measure blood pressure and heart rate. Following data collection, participants were thanked by the research team and given a full debrief of the incident by the senior training instructors. For experienced personnel, this task was also one of the three tasks that would be undertaken during phase two.

5.2.3.2 Phase two

Experienced participants undertaking phase two of testing were all taking part in their bi-annual SCBA competency assessment that involved three SCBA wears over a two day period. Upon arrival at the BATC, participants were greeted, given an overview of the procedures to be followed and asked to read and sign an informed consent form, and have read and understood the 'information for participants' booklet. At this point participants were given the opportunity to ask any questions and also an explanation of the information they would gain as a result of their participation in the study.

Prior to beginning any task, an exercise brief was delivered to all participants in the classroom of the breathing apparatus training centre. Experienced training officers selected the teams of two, three, or four persons that would be taking part in each activity, and described the task that was to be completed in each exercise, as well as covering key health and safety considerations. Standard Operating Procedures (SOP) were adhered to and safety officers also wearing SCBA were to be in attendance at all times.

The scenarios were identical for each of the teams. In order to complete the free search exercise, the scenario was for a team to enter a structure set out as a single story flat via a third story door (identified in figure 5.2). The team then had to search all of the compartments within the premises for persons known to be trapped inside and rescue the occupiers (a 90kg dummy with a 5kg baby dummy placed side by side). To ensure consistency, the dummies were placed back in the exact same location within the structure by SCBA instructors prior to the next team entering.

In order to complete the guideline exercise, the structure was set up as a single story, large industrial unit post fire. Crews were required to make entry on the ground floor, traverse a pre-laid guideline, use correct search technique to locate persons known to be missing (in this scenario a single 55kg dummy), and remove them to a place of safety. Again, to ensure consistency, the dummy was placed back in the exact same location within the structure by SCBA instructors prior to the next team entering.

During day 1, SCBA teams were randomly allocated to complete either the free search or guideline exercise in the morning, followed by the alternative exercise to be conducted in the afternoon. On day two with only one live fire exercise taking place, new SCBA teams of two, three or four participants per team were randomly selected by training officers, as well as the order of entry into the live fire scenario the crews would enter. There was no set rest period prescribed between SCBA wears. Upon completion of the safety briefs, all participants completed the Bond-Lader mood scale, and had their heart rate and blood pressure taken by the researchers in the classroom.

All participants were then given time to service their breathing apparatus sets, which took approximately 10 minutes, and given time to change into their personal protective clothing (PPE) of tunic, overtrousers and fireboots, flash hood, gloves and helmet. Upon request from the training officers, each individual team were required to immediately don their SCBA sets, start up their air supply, check each other for any gaps in clothing, and enter the building with an experienced instructor who was there to act as an assessor and additional safety officer but who provided no assistance or advice on the task. Entry was made via one of three entry points (as displayed in figure 5.2), and at this point the researcher would collect the air pressure in the BA set and note the time on entry into the structure.

Immediately following withdrawal from the BA training structure, which could either be done by completion of the pre-determined task, or by indicating to the safety officer they were unable to continue, a single researcher would view the air pressure in the SCBA set and observe the time of exit from the training structure. Participants in that team would turn off and remove their SCBA set and were then asked to verbally report their highest perceived rate of exertion (PRE) during the task using the Borg Scale (Borg, 1970). Participants would then complete the Bond-Lader mood scale and NASA-TLX, the researcher would take a record of blood pressure and heart rate, and participants would receive a formal exercise debrief from the fire service training officers

This same procedure was then repeated for each of the following two tasks over the two-day period. The live fire task on day two was the same as the phase I live firefighting scenario. The brief was to enter the property (set up as two-storey residential premises) on the ground floor through a double door, locate the seat of the fire, extinguish the fire, and rescue any persons inside the building (in this scenario a single 90kg dummy).

All three tasks had to be passed at a standard assessed by the SCBA instructor to allow the firefighter to pass the course and maintain their 'competent SCBA wearer' status. Following culmination of data collection on the second day, participants were thanked by the research team, given a full debrief of the study, and given the opportunity to ask any questions related to the study.

5.2.4 Treatment of data

In phase one, in order to test the differences between the status (novice or experienced) and background levels of stress scores a one way ANOVA was utilised. Following exploration of data, to establish the pre-post firefighting task differences in novice and experienced firefighters' physiology and mood, a mixed model ANOVA was employed. Post hoc analysis utilising Bonferroni tests were conducted when appropriate.

For phase two, repeated measure ANOVA's considering time (pre-post), task (guidelines, live firefighting, and search and rescue), and task x pre-post interaction were employed, and post-hoc analyses were conducted utilising Bonferroni tests when appropriate. An alpha level of .05 was employed.

5.3 Results

The primary aim of this study was to identify the physiological and psychological impact of specific SCBA exercises upon firefighters. The results section is presented in two separate sections.

The first section presents the results from phase one of the study, exploring the effects of a live firefighting exercise upon novice and experienced firefighters. The second part of the results section presents the physiological and psychological findings from experienced personnel taking part in three specific SCBA tasks over a two-day period.

5.3.1 Phase one results

Each of the two participant teams completed the same task, following a brief of 'house fire, persons reported' outside the structure. This included the use of live firefighting skills using hose reels to extinguish the fire whilst wearing SCBA in temperatures of ~180^{0} C for the duration of the task. The time taken to complete the tasks was an average of 31 minutes for novice firefighters, whilst experienced firefighters completed this same task in an average of 19 minutes from point of entry to time of exit.

5.3.1.1 Physiological measurements

Descriptive statistics of the physiological measures taken following completion of the single live firefighting exercise can be found in table 5.1.

Heart rate

Table 5.1 demonstrates that post task increases in the heart rate of both novice (pre mean = 84 bpm; post mean = 144 bpm) and experienced firefighters (pre m = 70 bpm; post m = 98 bpm). Statistical analysis demonstrated a significant main effect of novice or experienced firefighter stage upon heart rate ($F (1, 17) = 41.634$, $p < 0.01$, partial $n^2 = 0.710$). There was a significant effect of time upon heart rate ($F (1, 17) = 122.154$, $p < 0.01$, partial $n^2 = 0.878$), and a significant interaction between pre-post changes in heart rate and firefighter status ($F (1, 17) = 19.034$, $p < 0.01$, partial $n^2 = 0.528$). Bonferroni post hoc analysis demonstrated that significant increases in heart rate in both novice ($p < 0.01$) and experienced firefighters ($p < 0.01$). The means displayed in table 5.1 show that the increases in heart rate were greatest in novice firefighters.

Table 5.1. Means (and standard deviations) of the physiological measures of heart rate and blood pressure pre and post completion of a live firefighting task undertaken by novice and experienced firefighters.

	Novice (*n* = 7)		**Experienced (*n* = 12)**	
	Pre	**Post**	**Pre**	**Post**
Heart rate (bpm)	79 (8)	144 (22)*	70 (8)	98 (12)*
Diastolic Blood pressure (mmHg)	80 (4)	69 (11)	80 (10)	79 (19)
Systolic Blood pressure (mmHg)	131 (8)	126 (16)	138 (16)	143 (23)

*= $p < 0.05$

Blood pressure

There was a very slight increase in systolic blood pressure post task (pre m = 138 mmHg; post m = 143 mmHg) in experienced firefighters and a decrease in systolic blood pressure (pre m = 131 mmHg; post m = 126 mmHg) in novice firefighters. Statistical analysis found a significant main effect of firefighter status upon systolic blood pressure (F (1, 17) = 5.198, p = 0.036, partial n^2 = 0.234), although there was no significant effect of time upon systolic blood pressure (F (1, 17) = 0.002, p = 0.962, partial n^2 < 0.01), or significant interaction between pre-post changes in systolic blood pressure and firefighter status (F (1, 17) = 0.739, p = 0.402, partial n^2 = 0.042).

Diastolic blood pressure of firefighters decreased in both experienced (pre m = 80 mmHg; post m = 79 mmHg) and novice (pre m = 80 mmHg; post m = 69 mmHg) samples. Statistical analysis found no significant main effect of novice or experienced firefighter status upon diastolic blood pressure (F (1, 17) = 0.773, p = 0.392, partial n^2 = 0.43), nor a significant effect of time upon diastolic blood pressure (F (1, 17) = 2.995, p = 0.12, partial n^2 = 0.150), and there was no significant interaction between pre-post changes in systolic blood pressure and firefighter status (F (1, 17) = 2.236, p = 0.153, partial n^2 = 0.116).

Perceived effort

The Borg Scale was incorporated to allow novice (m = 15.7) and experienced (m = 14.6) participants to provide a self-rated measure of perceived exertion of the task. Using a between subjects ANOVA, there was no significant effect of firefighter status upon on the levels perceived exertion reported (*F* (1, 17), = 1.167, p = 0.295).

5.3.1.2 Psychological measurements

Descriptive statistics of the psychological measures taken following completion of the single live firefighting exercise can be found in table 5.2.

Table 5.2. Means (and standard deviations) of self-reported measures of alertness, calmness, and contentedness pre and post completion of a live firefighting task undertaken by novice and experienced firefighters as measured by the Bond-Lader Inventory (1974).

	Novice (*n* = 7)		**Experienced (*n* = 12)**	
	Pre	**Post**	**Pre**	**Post**
Alertness	72 (14)	43 (7)*	80 (13)	74 (12)
Calmness	31 (10)	53 (19)	71 (16)	55 (19)*
Contentedness	62 (19)	44 (22)	78 (16)	75 (13)

*= $p < 0.05$

Mood

There were post task decreases in the self-rated levels of alertness in both novice (pre m = 72; post m = 43) and experienced firefighters (pre m = 80; post m = 74). Statistical analysis demonstrated a significant main effect of firefighter status upon levels of alertness (F (1, 17) = 15.678, $p < 0.01$, partial $n^2 = 0.480$). There was also a significant effect of time upon alertness (F (1, 17) = 33.876, $p < 0.01$, partial $n^2 = 0.666$), and a significant interaction between pre-post changes in alertness and firefighter status (F (1, 17) = 16.062, $p < 0.01$, partial $n^2 = 0.486$). Subsequent post hoc analysis utilising Bonferroni tests revealed that the live firefighting task produced a significant decrease in alertness in novice firefighters ($p < 0.01$), but not found in experienced firefighters ($p = 0.108$), as demonstrated by the mean scores in table 5.2.

Self-rated levels of calmness demonstrated post task increases in novice firefighters (pre m = 31; post m = 53) and decreases in calmness levels in experienced firefighters (pre m = 71; post m = 55). Statistical analysis demonstrated a significant main effect of firefighter status upon levels of calmness

(F (1, 17) = 12.689, p = 0.002, partial n^2 = 0.427). Whilst there were no significant effects of time upon levels of calmness (F (1, 17) = 0.181, p = 0.676, partial n^2 = 0.11), there was a significant interaction between pre-post changes in calmness and firefighter status (F (1, 17) = 11.564, p = 0.003, partial n^2 = 0.405). Post hoc analysis utilising Bonferroni tests demonstrated that the live firefighting task produced a significant decrease in the self-reported calmness levels of experienced firefighters (p = 0.024), but no significant change in the self-reported calmness levels of novice firefighters (p = 0.072).

Finally, there were post task decreases in the levels of self-rated contentedness in both novice (pre m = 69; post m = 44) and experienced firefighters (pre m = 78; post m = 75). Statistical analysis demonstrated a significant main effect of firefighter status effect upon levels of contentedness (F (1, 17) = 10.468, p = 0.005, partial n^2 = 0.381), and a significant effect of time upon contentedness (F (1, 17) = 11.965, p = 0.003, partial n^2 = 0.413), but no significant interaction between pre-post changes in contentedness and firefighter status (F (1, 17) = 3.187, p = 0.92, partial n^2 = 0.158).

5.3.2 Phase two results

5.3.2.1 Physiological measurements

Descriptive characteristics of the physiological measurements for phase two tasks are provided in table 5.3. The mean time taken to complete the tasks was 17 minutes for search and rescue, 14 minutes for guidelines, and 19 minutes for the live firefighting task. Guidelines required greatest air consumption at 8.4 bar/min minute, followed by search and rescue (7.2 bar/min) and live firefighting (5.9 bar/min).

Heart rate

There was no significant main effect of the type of task on heart rate (F (2, 18) = 1.733, p= 0.205, partial n^2 = 0.16). There was however, a significant main effect of time (F (1, 18) = 120.298, p < 0.01, partial n^2 = 0.930), and also a significant interaction between the type of task and pre-post changes in heart rate (F (2, 18) = 3.690, p = .045, partial n^2 = 0.291). All three tasks completed by participants led to significant increases in heart rate. Subsequent Bonferroni post hoc analysis revealed that the three conditions all produced significant increases in heart rate during live firefighting (p < 0.0001), guideline (p = 0.001) and search and rescue (p = 0.005) tasks.

Table 5.3. Pre and post means (and standard deviations) of physiological measures pre and post task (n = 12) when undertaking guideline, search and rescue, and live firefighting tasks.

	Guideline		**Search and Rescue**		**Live firefighting**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Heart rate (bpm)	84 (11)	104 (19)*	91 (21)	104 (18)*	70 (8)	98 (12)*
Systolic blood pressure (mmHg)	141 (14)	154 (17)	136 (15)	156 (12)	138 (16)	143 (23)
Diastolic blood pressure (mmHg)	78 (16)	96 (12)*	87 (10)	96 (11)*	80 (10)	79 (19)
Air pressure (bars)	287	181	291	169	292	187
Time in task (mins)	n/a	13.9	n/a	17.0	n/a	19.0
Air consumption per minute (bar/min)	n/a	7.6	n/a	7.5	n/a	5.5

*= $p < 0.05$

Blood pressure

There was a significant main effect of task upon systolic blood pressure (F (2, 18) = 0.291, p= 0.751, partial n² = 0.31). The main effect of time was significant (F (1, 9) = 9.203, p= 0.014, partial n² = 0.506), although there was no significant interaction found between the type of task and pre-post changes in systolic blood pressure (F (2, 18) = 1.265, p= 0.306, partial n² = 0.123).

There was no significant main effect of the type of task upon changes in diastolic blood pressure (F (2, 18) = 0.1.735, p= 0.205, partial n² = 0.162). However, there was a significant main effect of time (F (1, 9) = 8.671, p= 0.016, partial n² = 0.491) and a significant interaction between the type of task and pre-post changes in diastolic blood pressure (F (2, 18) = 4.795, p= 0.021, partial n² = 0.348). Pre-post changes in diastolic blood pressure were characterised by significant increases following guideline (p = 0.002) and search and rescue (p = 0.014) tasks, but no significant changes following the live firefighting task (p = 0.868).

5.3.2.2 Psychological measurements

Mood

All twelve participants completed a series of mood assessments prior to and immediately following each of the three tasks. Table 5.4 provides descriptive statistics for pre and post task changes in mood following participation in guideline, search and rescue, and live firefighting tasks. Of the three tasks, self-rated levels of calmness following completion of a guideline exercise increased; with the means score of alertness and calmness both decreasing after each task.

Table 5.4. Means (and standard deviations) of task induced changes in mood following completion of guideline, search and rescue, and live firefighting tasks (*n*=12)

	Guideline		**Search and Rescue**		**Live firefighting**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Alertness	76 (13)	75 (15)	75 (16)	73 (16)	80 (13)	74 (12)
Calmness	67 (16)	68 (17)	69 (19)	57 (13)	71 (16)	55 (19)
Contentedness	74 (15)	72 (16)	76 (18)	72 (14)	78 (16	75 (13)

A 2 x 3 repeated measures ANOVA (level x type of task) revealed that there was no significant main effect of type of task ($F (2, 18) = 0.171$, $p= 0.844$, partial $n^2 = 0.19$) or time ($F (1, 9) = 1.036$, $p= 0.335$, partial $n^2 = 0.103$) upon participants self-rated levels of alertness. There was no significant interaction between the type of task and pre-post changes in alertness ($F (2, 18) = 0.355$, $p= 0.706$, partial $n^2 = 0.038$).

There were no significant main effects of the type of task ($F (2, 18) = 0.196$, $p= 0.824$, partial $n^2 = 0.21$) in levels of calmness. Although pre-post changes in calmness were found to be significant ($F (1, 9) = 17.154$, $p <0.01$, partial $n^2 = 0.656$), there was no significant interaction was produced between the type of task and pre-post changes ($F (2, 18) = 1.674$, $p= 0.215$, partial $n^2 = 0.157$).

Finally, there was no significant main effect of type of task ($F (2, 18) = 0.113$, $p= 0.894$, partial $n^2 = 0.12$) on levels of contentedness. Although there was a significant main effect of pre-post changes ($F (1, 9) = 6.533$, $p= 0.031$, partial $n^2 = 0.421$), there was no significant interaction between the type of task and pre-post levels ($F (2, 18) = 0.063$, $p= 0.215$, partial $n^2 = 0.007$).

Perceived workload and perceived effort

Participants were required to provide ratings of the factors that made the task demanding and the level of effort required to successfully complete the task immediately after undertaking each of the three exercises. Table 5.5 provides the means and standard deviations of the NASA-TLX which was used to measure six domains of perceived workload (mental demand, physical demand, temporal demand, effort, performance, and frustration) self-perceived by participants by scoring from 0 (low) to 100 (high). Also provided are the mean scores from the Borg Scale completed post task.

Firefighters stated that they found the live firefighting task to require the marginally more mental effort (m = 75) than search and rescue (m = 74) or guideline (m = 72) tasks. Highest levels were also found for ratings of physical demand (m = 78), temporal demand (m = 67), effort (m = 78), and performance (m = 83) during live firefighting tasks.

Table 5.5. Means and (standard deviations) of post task, self-perceived facets of workload (as measured by the NASA-TLX) and effort (as measured by the Borg Scale) (*n* = 12) in guideline, search and rescue, and live firefighting tasks

	Guideline	**Search and Rescue**	**Firefighting**
Mental demand	72 (11)	74 (22)	75 (19)
Physical demand	66 (18)	61 (20)	77 (15)
Temporal demand	61 (15)	60 (14)	67 (15)
Effort	71 (17)	68 (19)	78 (13)
Performance	73 (20)	74 (13)	83 (7)
Frustration	40 (21)	36 (20)	38 (22)
Borg Scale	13 (1.9)	13 (1.7)	15 (2.1)*

*= $p < 0.05$

Levels of frustration were marginally higher in guidelines (m = 40) than in live firefighting (m = 38) search and rescue (m = 36). However, statistical analysis revealed no significant main effect of task for self-perceived levels of mental demand (p= 0.911), physical demand (p= 0.51), temporal demand (p= 0.293), effort (p= 0.136), performance (p= 0.192), or frustration (p= 0.924).

The main effect of task on perceived physical effort (as measured by the Borg Scale) approached significance ($F(2, 22) = 4.545$, $p = 0.055$, partial $\eta^2 = 0.292$). However, Bonferroni post hoc analysis found that live firefighting tasks were perceived to be significantly more physically demanding than search and rescue tasks ($p = 0.031$), although no significant differences were found between guidelines and live firefighting ($p = 0.089$), or search and rescue, and guideline tasks ($p = 1.000$).

5.4 Discussion

Due to this study being a combination of two phases of testing, the discussion is split into three sections. The first section summarises the findings of firefighter status upon physiological and mood responses during a single live fire task, whilst the second section of the discussion further describes the outcomes of experienced firefighters undertaking a range of common SCBA tasks. Finally, the third section brings the two phases together to describe the methodological issues associated with data collection during SCBA training exercises, as well as the general recommendations arising from the findings and future directions for research.

5.4.1 Phase one findings

The aim of phase one was to establish the physiological demands of a live firefighting task in novice and experienced firefighters, and to determine the self-reported effects of live fire upon mood states of novice and experienced firefighters. Both novice and experienced participants in this study were able to complete the tasks in full and meet the task objective, although trainee firefighters were exposed to the live fire environment (31 minutes) for an average of 12 minutes longer than the experienced firefighters (19 minutes). However, these variances in the time taken to complete the task should not be taken as an indicator of firefighter ability or performance, and it is argued that taking longer to complete the task does not represent poorer performance but perhaps a more thorough search of rooms during the task (Williams-Bell et al., 2010). As the experienced firefighters were able to complete the task quicker, it could be suspected that this may be attributed to experience of completing similar tasks and being able to work more efficiently as identified in chapter 3. Alternatively there is the risk that the experienced group were aware that it was just a training exercise and that they were going through the routine of the task instead of undertaking a more thorough, methodological approach.

5.4.1.1 Physiological measurements

Results demonstrated that both novice and experienced firefighters undertaking a single live fire training exercise experienced significant increases in heart rate post task. The increase in heart rate in elevated temperatures was expected and is consistent with earlier UK firefighter research by Rayson et al. (2005) and Carter et al. (2007) who have both reported significantly greater heart rate and perceived exertion during hot conditions. Following completion of the task, novice firefighters were measured by the research team at working at 74% of their age-related maximum heart rate (as predicted by the 220-age formula, Astrand & Rodahl, 1986), in comparison with the experienced firefighters who were measured at 54% of their age-related maximum heart rate. Both of these rates are lower than previously recorded levels in simulated live fire conditions, such as a mean heart rate of 90% of their participants' age predicted maximum (Holmer & Gavhed, 2007). However, trainee firefighter heart rate levels were consistent with a boundary cooling task utilised by Bilzon et al. (2001) eliciting 77% of their maximum heart rate, and a 34 minute hot fire task requiring 69% of participants' maximum heart rate (Rayson et al., 2007), although as identified in the literature review, caution is advised when this calculation of age predicted maximum heart rate is utilised.

However, what is yet to be determined from the findings of the study undertaken is if post task differences between the novice and experienced firefighters were a result of the physiological demands of the heat, the psychological stress associated with the task (such as fear or anxiety), or a combination of both. Even experienced firefighters may suffer from increases in heart rate attributable to psychological factors. For example, Matthews et al. (2000) describe how previous experience of physical stressors may lead to an increase in the individual's psychological stressor of fear as they know what to expect from the task, particularly if it is likely to be extremely demanding.

There was little difference between the pre-task heart rates of the novice and experienced firefighters, with both recording relatively lower pre-task mean heart rate levels. It was expected that novice firefighters' heart rates would have been elevated pre-task due to the arousal-activated impact of inexperience of the live fire environment, with Rayson (2005) suggesting that cognitive factors such as uncertainty and apprehension will undoubtedly influence physiological parameters such as heart rate. In addition, the notion of increased arousal in early career has also been demonstrated both in chapter three of this research, and also by novice parachutists by Fenz and Epstein (1967). Experienced firefighters were expected to have lower pre-task heart rates, as demonstrated in this study, due to an 'inhibition of fear' that is achieved through previous experience demonstrated, as found in experienced parachutists prior to an airplane jump (Fenz & Epstein, 1967).

A possible explanation for the similarities in pre-task heart rates of the two groups in this study may be due to the measure of heart rate being taken approximately 15 minutes before undertaking the firefighting task, unlike Fenz and Epstein (1967) who measured novice parachutists' heart rate right up to the time just before jump exit from the aircraft. Therefore, it is possible that arousal / heart rate levels may have steadily increased at a greater level in novice firefighters immediately prior to entry to the SCBA task, although the increased physiological demand of wearing firefighting PPE and SCBA to walk to the entry point may have increased this heart rate and provided a misleading measure in both novice and experienced personnel, due to the increased demand of carrying up to 30kg of PPE and SCBA equipment (Cheung et al., 2010).

In contrast to previous research such as Smith et al. (2008), there were no significant changes in either systolic or diastolic blood pressure. Mean scores demonstrated a post task decrease in the diastolic blood pressure of both novice and experienced firefighters, and an increase in the post task systolic blood pressure levels of experienced firefighters but a decrease in the systolic blood pressure of novice firefighters, although the high variance and low participant numbers suggest that results should not be generalised outside of this very limited sample. Findings are consistent with Marshall (2003), who suggests that cardiac output and cardio-respiratory responses during firefighting operations cause fatigue and create a significantly heightened demand for delivering oxygen to the tissues. Marshall (2003) also suggests the importance of maintaining blood pressure response but not at an excessive pressure, whilst a decrease in blood pressure can be a warning sign, as this can indicate fatigue and declining cardiac output. Such effects may have been expected in the participant groups of this study who would have been reaching their physical limits after the amount of exposure to a novel heat.

Further validation of the demands of firefighting was provided through self-reported levels of effort required to complete the task using the Borg Scale (Borg 1970). A live firefighting mean of approximately ‘15’ by the experienced personnel is classified as around 80% effort required (‘hard’), and is comparable with the score of around ‘16’ (85% effort) reported by novice firefighters, and those found by Smith et al. (1996) following a 16 minute drill in hot conditions who reported an RPE of 16 on the Borg scale. Self-reported Borg scale levels were also consistent with the mean score of 16.3 +/- 2.4 reported by Elgin and Tipton (2003) after a 40 minute live fire exercise by experienced firefighters, suggesting that SCBA tasks in live fire conditions are perceived by firefighters to be similarly demanding regardless of their length of service or time spent completing the task.

5.4.1.2 Psychological measures

One of the key components for this study and its potential importance to firefighters was the inclusion of the self-reported alertness measure. The ability to maintain alertness whilst wearing SCBA is essential and can be considered a key element in informing the rapid decision making required by firefighters, particularly during live firefighting due to the increased risk of burns and thermal injuries. Reduced or impaired levels of alertness should also serve to inform the firefighter and officer in charge of the potential for increased risk of injury or disorientation if a SCBA redeployment task is necessary at an incident.

Following completion of the live firefighting task, results demonstrated that there was a significant decrease in the self-reported levels of alertness of the novice firefighters, decreasing from approximately 72% to 43%, which is consistent with the demonstrated physiological responses indicating the onset of fatigue previously discussed. The decreased levels of alertness found in novices may be attributed to the time spent undertaking the task compared to the experienced firefighters whereby increased exposure to the hot environment may have created fatigue and impacted levels of alertness.

The relatively small decrease in alertness levels from 80 to 74% in experienced firefighters suggests that adaptation to live fire environments may exist in experienced personnel, although Love et al. (1994) have identified that since UK firefighters wear SCBA less than once per week they probably do not develop or maintain any specific physiological tolerances to SCBA wearing. One possible explanation for the consistent levels of alertness in experienced personnel is provided by the attentional theory of performance proposed by Hancock (1986). Describing how increased temperature change is associated with performance impairment due to physiological stress draining attentional resources, Hancock (1986) suggests that skilled performers are resistant to the effects of heat through automisation of their skills reducing this requirement for attentional resources. In this study, the increased demand for novice firefighters to attend to all available cues during the task (such as the location of doors and windows, their search technique, and regular communications with the other SCBA wearers) in the heat may have led to a cognitive demand to maintain high levels of alertness, which through physiological demand of the heat, became fatigued and reduced. In contrast, the experienced firefighters may have been able to autonomise their skills (such as SCBA search technique) and as such may have placed less of a demand upon their attentional resources, and thus maintaining higher levels of alertness post task. This was demonstrated by the significant rise in heart rate by experienced firefighters but no significant impact upon self-rated levels of alertness.

There was a significant decrease in the post task levels of calmness in experienced firefighters. This is consistent with findings found in chapter 3 where firefighters being interviewed about mid-career stage stressors (~15 years' service) reported the fear of making a mistake in a training environment (such as this one), particularly given that the mean length of service for the experienced firefighters in this study was approximately 14 years. As a result, the decrease in levels calmness may be due to the fear and apprehension of the post task debrief, whereby an experienced firefighter has the skills to complete the task but is nervous about feedback from training school instructors. The task undertaken in this study was part of a bi-annual assessment and therefore although the experienced personnel may have experience in live firefighting, they may have relatively low levels of experience performing in front of training school instructors. Alternatively, Sommer and Nja (2011) have identified that in critical situations, firefighters are seldom able to behave in a way that they have been told about but instead tend to adapt the responses to approaches they have experienced themselves which have led to satisfactory outcomes. A training situation is unlikely to be considered to be a critical situation and therefore having to intentionally adapt their SCBA techniques to the way that have previously been taught and read may have also to increased frustration and reduced levels of calmness in this group.

In comparison, the novice firefighters in this study had previously completed two weeks of SCBA training under ambient conditions, and therefore had undertaken (and passed) at least three previous exercises before being allowed to undertake a live firefighting task. Consequently, they may be more experienced at being assessed at training school than the experienced firefighters. Therefore the absence of significant changes in the self-reported levels of calmness of novice firefighters may reflect the relief at completing the task, and not as much apprehension about the debrief from training instructors. The findings of this study are consistent with those in chapter 4 when a comparable sample of novice firefighters at training school reported that observation stressors included ‘pressure to pass’, and ‘being observed by training staff’. Both of these stressors can be considered to be present pre-task but not post task, when the observations have been completed and the firefighters have complete the task by virtue of it not being stopped for safety / performance reasons. Although both groups of firefighters demonstrated a decrease in post task levels of contentedness, there was no significant interaction found between status and pre-post task changes.

5.4.2 Phase two findings

5.4.2.1 Physiological measures

Heart rate and blood pressure

There were found to be significant increases in heart rate after each of the three tasks, with firefighters found to be working at approximately 58% of their age predicted maximum heart rate (Astrand & Rodahl, 1986) during search and rescue and guideline tasks, and 54% during the live firefighting task. An increase in heart rate in all three tasks is consistent with previous research by Fernhall et al. (2012) who found that an increase in heart rate occurred during multiple repeated SCBA wears, although Fernhall et al. (2012) also reported maximal heart rate occurring in participants during each of the five times that participants were actively taking part in tasks.

The age predicted maximum heart rates observed in this study were lower than those in previous research such as Romet and Frim (1987) who reported that simulated firefighting tasks search and rescue tasks are the most demanding and led to participants working at 85% of their age predicted maximum. Even during ambient temperatures maximum heart rates have been measured at 91% of the participants' age predicted maximum (Williams-Bell et al., 2010), although this latter task was primarily involved with stair climbing in SCBA and carrying equipment.

Mean heart rates recorded post task levels of 104 bpm (guidelines), 103 bpm (search and rescue) and 98 bpm (live firefighting) are lower than those reported in previous studies. Previous studies have reported mean heart rates of firefighters as 150 +/- 13 beats per minute during a six floor rescue of hospital patients (Von Heimburg et al., 2006), 182 +/- 20 bpm during a simulated rescue task after a 40 min live fire training exercise (Elgin & Tipton, 2003), 182 bpm after live fire drills in a training environment (Smith et al., 1996) and 177 +/- 23 bpm during a large fire simulation structure, where 7 of the 49 firefighters taking part exceeded their age predicted maximum (Angerer et al., 2008). In contrast to the only previous study of a guideline task where heart rates of 145 bpm were recorded (Brewer, 1999), a mean of 104 bpm was recorded for the participants of this study, although the firefighters in the Brewer (1999) task were wearing SCBA during the exercise for over 6 minutes longer than the participants of this study. The greatest increases in mean heart rate in this study were observed following live firefighting. However, increases in heart rate of 8 bpm (between live firefighting and guidelines) and 15 bpm (between live firefighting and search and rescue) were not as great as increases observed in live fire conditions (average of 175 bpm compared to 139 bpm in ambient conditions) reported by Smith et al. (1997).

It is acknowledged that increased temperatures can lead to increased heart rate. For example, Rayson et al. (2007) found a heart rate of 69% maximum in a hot fire task compared to 56% of participants in a cool task, whilst Barr et al. (2010) have suggested that even in the absence of high temperatures, the endogenous heat production is sufficient for imposing heat strain when the activity is one of a strenuous nature. This suggests that in this study, radiated heat may have not been the factor in increasing heart rate, but instead is attributable to the heat produced through PPE. In addition, the absence of a control group undertaking the same tasks but under live fire or ambient conditions make it impossible to make a comparison between any heart rate increases being attributed to the changes in increased environmental conditions, or alternatively, different task demands of the activity.

Participants did not demonstrate any significant changes in systolic blood pressure, although significant post-task increases in diastolic blood pressure (DBP) after guideline and search and rescue tasks were observed. Findings are consistent with those of Webb et al. (2011) who suggested that increased cardiac output and the associated increased blood pressure occur to allow the body to be prepared to meet increased exertional demands of firefighting. However, these blood pressures changes were in contrast to previous studies of simulated firefighting and no participants were considered to be hypertensive, unlike those of Smith et al. (2008), where brachial blood pressure levels in 10% of firefighters were classified as hypertensive, whilst a further 65% of participants were considered pre-hypertensive after 18 minutes exposure to the firefighting task.

Increased heart rate and blood pressure may also be expected to increase in firefighters due to factors other than the physical or exertional demands of the task. Emergency service research by Kales et al. (2009) examining Police Officers suggests that high job demands and low flexibility in decision making results in Police Officers possibly experiencing periods of significant increases in their heart rate and systolic blood pressure. During this study, although participants faced high demands, there were extremely low levels of individual control and flexibility since they were being assessed by training officers against set standards to determine their on-going status of competence, yet at an operational incident, this level of control is likely to be further reduced. For example, when a casualty is in need of rescue, the firefighter will be given a brief by the officer in charge, and have very little opportunity to withdraw from a structure or deviate from their task brief has been completed, potentially leading to even higher heart rate or blood pressure responses than found in the three tasks explored in this study.

It is also unknown if blood pressure would change at operational incidents as a result of operational noise on-scene. Noise exposure to alarms, sirens, vehicle engines and mechanical rescue equipment, were not present during the exercises, with the exception of the fire engine mechanical pump. However, such exposures are estimated to produce a typical 8-hour time-weighted noise exposure in the 63-85 decibel (dBA) range, consistent intermittent exposures over 90dBA, and a recorded level of over 100 dBA (Kales et al., 2009). Van Kempel et al. (2002) describe how there is an increase of 0.51 mmHg in systolic blood pressure per 5 decibel increase in occupational noise exposure relative to an increase of around 5.9-11.8 mmHg attributable to siren noise although the researchers state that the duration of these effects is still to be determined.

With regards to a potential stable blood pressure, and in contrast to previous studies of endurance athletes in prolonged endurance events, such as Hassan et al. (2006), Fernhall et al. (2012) demonstrated that blood pressure was unaltered following a three hour firefighting task. Related to this, Fahs et al. (2009) examined the impact of acute exercise resistance, and observed a decrease in arterial compliance without changes in blood pressure 30 minutes after a bout of exercise resistance. Since many of the activities involved in fire suppression can be considered to mimic resistance training, this should not be considered entirely surprising, although the reasons for unaltered blood pressure in the current study remain unclear.

Finally, the time of day that blood pressure measurements were taken may also have influenced the results of this study. Jones et al. (2008) examined the reactivity of blood pressure following a given change in physical activities at a specific time of day. Using 12 normotensive physically active males undertaking 30 minutes of exercise on a cycle ergometer at 70% $\dot{V}0_{2max}$, participants were measured during a morning (0800hrs) and afternoon (1600hrs) session. Results showed that whilst post exercise hypotension was experienced as expected following afternoon exercise, the morning task displayed less marked blood pressure changes, with evidence of DBP increasing rather than decreasing during this period and persisting for a further 60 minutes of subsequent everyday activities. This provides support for post acute-exercise changes in blood pressure varying with the time of day, with higher levels of baseline heart rate and lower levels of blood pressure also observed during the morning phase of testing. In this study, due to groups and order of entry into the task dictated by training officers, and since half of the participants completed the guideline exercise in the morning and half completed the guideline exercise in the afternoon (and vice versa for search and rescue), any potential effect should have been minimised, although with all participants completing the live fire exercise in the morning this may have led to reduced blood pressure if the findings of Jones et al. (2008) are relevant to this sample. Due to the potential factors that influence blood pressure, further research into the blood pressure reactivity of firefighters in real life settings is recommended before any assumptions can be made from training environments.

5.4.2.2 Psychological measures

Mood and workload

Firefighters started each of the three tasks with a high level of self-reported alertness of approximately 75% of their maximum level, which was maintained at a similar level following completion of each of the tasks. As with the findings of phase one, the attentional theory of Hancock (1986) may account for these findings, whereby the firefighters' experience of these tasks led to an autominisation of skills that reduced the need for attentional resources that may lead to cognitive fatigue. Related to this, experienced firefighters reported high levels of calmness both pre and post task in each of the conditions, with Bond-Lader mood inventory scores showing post task decreases in search and rescue and live firefighting and a slight increase following the guideline task. This suggests that little pre-task impact or anticipation of being exposed to novel training environments and being assessed is present in experienced firefighters. However, post task decreases may be caused in part by the debrief held by the SCBA instructors regarding their techniques and performance, typically in an 'error identification' format (Joung et al., 2006), or frustration at having to adapt their 'adapted' technique used at incidents for assessment purposes (Sommer & Nja, 2011). Increases in calmness following the guideline task may be attributed to the feelings of relief associated with completing a task involving complex fine motor skills such as knot typing whilst wearing thick fire gloves in darkness.

However, the observed effects of increased calmness should not be taken as representative of firefighters levels of calmness at operational incidents. The nature of the course undertaken by the participants required that they were informed in advance of what to expect on each day. For example, they knew weeks in advance that there would be a guideline task under ambient temperatures on day one, and this knowledge was then reinforced by course instructors upon arrival, and then during the safety brief prior to the exercise. As such, the degree of uncertainty is less than those that would be expected at an operational incident, where a firefighter may be told the type of SCBA actions required by the officer in charge only seconds before they are deployed into the building. As a result it could be argued that levels of calmness under these conditions would be far less at operational incidents.

There were no significant effects of task type upon levels of contentedness in the sample. Mean scores demonstrated that all three tasks were associated with high levels of contentedness. This may be expected with firefighters who are used to the training environment, who will analyse their techniques and firefighting methods more so than at an operational incident and may be more reflective. However, the impact of this does contradict the notion of using an adapted technique to potentially explain the reduction in calmness.

Participant scores for the NASA-TLX revealed that, with the exception of frustration during guideline based task, live firefighting produces the greatest levels of self-perceived mental demand, physical demand, temporal demand, effort, and performance, although no significant main effect of task was found. Although there were relatively low levels of frustration created by the tasks, the finding that greatest levels of frustration were observed following the guideline task was expected. This is due to the application of fine motor skills rarely involved in other breathing apparatus tasks that are involved such as tying knots and clipping a belt-attached karabiner on and off a thin rope whilst wearing thick fire gloves and under obscuration.

5.4.2.3 Methodological issues of phase two

During phase two, no deliberate attempts were made at observing recovery strategies between tasks, and no attempts were made to standardise duration or type of rest period between tasks or record any fluid intake by firefighters despite the potential for amount of water or electrolyte fluid consumed to have an impact upon performance. Studies have shown that firefighters can lose up to almost a litre (or more) of sweat per hour (Selkirk et al., 2006). Psychologically, dehydration is associated with a decrease in a number of fundamental cognitive abilities such as short-term memory, working memory and visuo-motor abilities (Sharma et al., 1986) which may have accounted for the changes in alertness and contentedness found in this study. A study by Angerer et al. (2008) of 49 German firefighters undertaking a 30 minute simulated fire operation found that when asked about symptoms during the fire, 66% stated thirst, followed by 40% stating fatigue, suggesting the occurrence of a dehydrated state. Finally, in a study of 190 firefighters undergoing simulated activities under live fire conditions, the firefighters considered to be in dehydrated state demonstrated significantly greater cardiovascular strain than those in a euhydrated state (Brown et al., 2007).

Fernhall et al. (2012) has reinforced the need for firefighters to maintain hydration status even in environments of limited induced body water loses, suggesting that it is important to prevent decrements in cardiovascular performance, diminished work capacity, and risk for heat illnesses. Whilst the issue of hydration would not have been relevant for the single task of phase one, the consideration of post task rehydration was not considered in experienced participants despite undertaking three tasks over two days and the potential impact that dehydration may have had upon performance during the task. Simple measures such as nude weighting or urine colour charts provide an effective measurement device and should be considered in future research. However, observations by the research team, validated by course instructors, did verify that large quantities of water were available and consumed by all participants, although describing specific amounts would be speculative.

There have been numerous studies looking at the effects of intermittent bouts of exercise upon performance in sport and military settings, yet very few studies have considered the potential effects in firefighting. Of studies that have considered rest periods, the tendency has been to examine the ability of firefighters to immediately redeploy following completion of a SCBA task (Elgin & Tipton, 2003), or following controlled use of cooling strategies during a pre-determined rest period (Carter et al., 2007). Whilst military research suggests that a long duration rest (such as 24 hours) has no effect upon thermoregulatory responses of soldiers carrying out work the day after the rest periods (McLellan et al, 2002), the rest periods between the two tasks on day one or between day one and two of this study were not measured, with participants instead being allocated their entry to the task on a random basis by training officers. As a result, it is possible that groups of SCBA wearers may have had greater rest periods between tasks than other participants, with a potential impact upon the recorded pre-task levels of heart rate, blood pressure and mood.

It is possible that longer periods between tasks on day one may have led to a reduction in pre-task physiological responses due to increased rest, or alternatively may have led to an increase in pre-task physiological measures due to increased time for task apprehension or uncertainty. Further research is recommended to examine the impact of specific rest periods upon the physiological and psychological responses of firefighters during repeated SCBA wears. Unfortunately, due to the increased understanding (and usage) of cooling techniques that are recommended for firefighters such as passive recovery, rehydration, and clothing configurations (Barr et al., 2010), the establishment of rest period alone would be difficult to measure. In addition, the application of specific rest periods to training environments are not representative of the real life environment on the fire station where rest periods are random and determined by the frequency of call-outs.

5.4.3 Overall discussion

This section of the discussion aims to bring together the two phases of this study, in order to discuss methodological considerations and further explore confounding variables present when conducting future research. There are a number of factors that may contribute to the increase in heart rate observed in both phases of the study. For example, the rapid adjustment from stationary / light activity involved with lectures and checking SCBA sets to each of the task based activities would lead to increased sympathetic nervous system activation and subsequent increases in heart rate. Alternatively, other factors identified as increasing the heart rate of firefighters include heat, humidity, decreased oxygen, increased carbon dioxide and emotional factors not directly attributable to high physiological stress (Lemon & Hermiston, 1977). It is possible that the physiological findings reported in this study are representative of the rapid recovery rates of firefighters exposed to conditions for a shorter period of time, yet the delay from leaving the task, removing their SCBA set and fire tunic and the researcher placing the cuff over the arm to obtain measurement could have required around an extra 2-3 minutes to complete and increased the recovery periods of the participants. Furthermore, it is unwise to draw comparisons to other research, as noted by previous researchers such as Smith et al. (2001), who state that the differences in heart rates reported by different firefighter research studies are likely attributable to differences in the intensity of the firefighting task and radiant heat load.

5.4.3.1 Methodological considerations

Sample size and task

The small sample in the current study should be considered before generalisations are made. Variables could not be manipulated in either study to ascertain causal effects, and the study had to be conducted as passive observation that also included a lack of random assignment of participants to any conditions by researchers. However, the passive observation approach used in this study did maintain the validity of the training exercise undertaken by participants and allowed for the identification of potentially naturally occurring key variables that may play a role in a causal relationship.

One of the main limitations of this study has previously been identified in other studies that have attempted to utilise controlled training environments as representative of real-life situations (Williams-Bell et al., 2010), namely the firefighters subjective perceptions of the tasks undertaken. All of the SCBA activities in this study were performed as simulated emergencies only, and as such it is impossible to predict how real incidents alter the work rate and heart rate of a SCBA task prior to entry, or effect psychological responses such as temporal demands where the firefighter's know that there is no safety team or emergency exit on hand as at training school.

The firefighters in both phases of this study were asked to undertake the tasks at their normal working pace, although it is possible that they may have performed faster as they knew they were taking part in a research project and also being assessed by training school instructors. Conversely, participants in this study may have performed slower and more methodically as they knew that the casualty was only a mannequin and not a live person in need of rescue, and instead focused upon their technique in front of training officers. Firefighters considered to be in 'training mode' are usually fully aware that exercises are not real incidents and response, and a tendency observed by Sommer and Nja (2011) in their study of Norwegian firefighters was that the training exercises did not seem to present a sufficient challenge for the more experienced firefighters. Such responses have also been attributed to cardiovascular responses in military training environments (Lieberman et al., 2006), whereby, although physical challenges such as environmental conditions were representative of real life situations, there were a lack of factors that may cause a psychological response such as genuine risk to life, task uncertainty, and pressure from bystanders to act. This lack of challenge was attributed by Sommer and Nja (2011) to the training normally taking place in familiar settings, and seldom providing a novel content. However, it is also important that this need to match the real-life environment allows for both safety and standardisation considerations to be met to ensure that firefighters are capable of performing at a real-life incident (Webb et al., 2011).

Another limitation from this research is that it is unknown how closely the results (and the training scenario) represent those expected to be experienced at real-life incidents. Previous work in the US military by Friedman and Kienan (1992) suggest that practice under stressors improve performance under stress by improving control and coping skills, although it has been noted that firefighters will not generate training adaptations to SCBA wear during training exercises unless these training tasks are of a sufficient intensity, duration and frequency (Lusa et al., 2004). It is recommended that training should mimic the real-life environment and therefore mediate the effects of the stress response (Kavanagh, 2005). This notion of ‘adaptive capability’ (Kavanagh, 2005) has important implications for fire and rescue, where it is impossible to practice every single scenario that may be faced is crutial. Accordingly, the ability to apply knowledge and skills through training and experience can be applied to more complex and novel situations. Whilst these theories may question whether experienced firefighters (such as those in this study) actually learn from these training exercises, within the populations of new and inexperienced firefighters, however, training exercises are considered to be a great opportunity to gain experience and become socialised into the existing culture (Sommer & Nja, 2011).

Physiological measurement

Another of the methodological considerations for both phase one and two of this study relates to the methods of measuring physiological responses pre, during and post task. In particular, measures of heart rate and blood pressure were carried out through use of an automated oscillometric device involving an inflatable cuff placed over the upper arm. This involved the participants removing their SCBA set and then firefighting tunic before measurement could take place and this potentially increased the duration of the post task recovery interval. In addition, this technique only provides a single assessment of HR and BP at each sample point and does not allow for continuous recording during the tasks. Similarly, when measuring BP levels through the use of oscillometric methods, incorrect cuffing around the bicep can also provide inaccurate reading, particularly in individuals with highly muscular compositions. This may present a problem within firefighting populations, with O’Brien (2011) reporting that under-cuffing of large arms accounts for 84% of miscuffings in outpatient clinics, whilst additional considerations such as accidental movement of the limb may impair measurement and very low pressures may not be measured accurately (Ward & Langton, 2007). The use of continuous non-invasive heart rate and blood pressure monitoring or blood pressure measurements using a manual sphygmomanometer may have reduced the impact of these issues.

In addition, thermocouples attached to the roof of the SCBA structure provided a measure of environmental heat experienced by the participant; however, research suggests that these devices may not accurately reflect this temperature. For example, Elgin et al. (2004) found that higher temperatures were reported from thermocouples attached to a metal pole positioned at heights of 0.3, 0.6, 0.9, 1.2, 1.5 and 1.8m above ground compared to thermocouples attached to the hip and shoulder of SCBA instructors, leading to an overestimation of the temperatures experienced by firefighting personnel.

The measurement of additional physiological parameters may have also provided relevant information. For example, as an indicator of total body hydration, nude weighting pre and post task provides a cost-effective and accessible measure, alongside measures such as urine colour charts. In addition, core body temperature was not measured, although the frequency of usage in recent firefighter research that has utilised gastrointestinal temperature transmitter pill (i.e. Fernhall et al. 2012) suggest this is a practical and valid way of assessing the impact of radiated heat upon firefighter responses carried out in the field. Given the identification of heat and core temperature upon increases in heart rate when exercising in the heat (i.e. Gonzalez-Alonso et al., 1999), the use of core body temperature monitoring may allow for inferences upon the impact of heat, in addition to psychological stress upon firefighter responses. Further studies and follow up research is strongly recommended to utilise core body temperature, continuous heart rate and blood pressure measurement, and nude weighting when conducting physiological measurement of firefighters during SCBA training exercises.

5.4.3.2 Generalisation of findings

Despite the potential limitations of the methodology, the sample size used in this study was in line with previous firefighter research (Smith et al., 2001; Carter et al., 2007; Jones et al., 2008) and provided a degree of control that allowed the research team to consistently ensure that measurements could be taken upon immediate exit from the task. Although participants were only inside the structure for up to 30 minutes, the total time for changing into fire kit, undertaking the task, study questionnaires, instructor debrief and set servicing including fluid and air cylinder replacement was often over an hour for each team. In addition, constant monitoring of the fire ground and identification of teams was required, as all teams were all dressed in identical clothing with faces covered by SCBA masks. Use of more than 12 participants per day, or two SCBA teams inside the structure at any time would not be recommended in further studies.

The tasks used were not exhaustive of all conditions in which SCBA would need to be worn, although working conditions, such as temperature, casualty body mass, PPE, and task duration were all considered representative of what would be expected at a real life incident by training officers. These tasks represent the current protocol for the validation of firefighters as competent SCBA wearers (for both novice firefighters at training school and experienced firefighters undertaking validation training). The tasks and the conditions inside the structures were designed by senior instructor and training officers to simulate a real incident as closely as possible as thus are considered valid and reliable tasks that are of benefit to the firefighter. However, the generalisation of findings of SCBA studies have been acknowledged as being highly task dependent, and as such great care is needed to transfer findings from one study or occupational group to another (Rayson, 2005). In the UK there are no standardised protocol or exercise briefs for SCBA training exercises, and as such tasks will vary according to the locations (or participating fire and rescue services) that took part in the study.

5.4.3.3 Measurement tools

Despite the limitations discussed within this chapter, the physiological measures used in this study were able to be carried out in a rapid and non-intrusive manner and the measure of pre and post heart rate and blood measurements have formed the methodology of the majority of firefighter studies measuring physiological responses in firefighters (i.e. Smith et al., 2001). As such, the techniques for measuring heart rate and blood pressure are now inexpensive and relatively simple, and have the potential to provide invaluable information regarding firefighter task demands to the individual, incident commander, and training officers. Yet despite the number of SCBA tasks performed each day physiological measurements represent an underused source of information outside of academic environments.

Gravelling et al. (2001) report that it is not common practice for fire services or training officers to monitor firefighters during heat training, despite 83% of instructors and 74% of trainee firefighters being exposed to hot training conditions for more than 5 minutes more than once per day. This figure increases for training officers, who will typically be exposed to between one and three SCBA session of 20 minutes duration per day. Of the few fire services that did take physiological measurements of their firefighters, the most common measurements were heart rate (18%) or core body temperature (17%), whilst mental impact of the training was assessed by only 13% of UK FRS's although it was not stated how this was achieved (Gravelling et al., 2001). In overseas fire services, of those questioned, only Finland-based fire services measured heart rate (although as a descriptive measure of exercise exertion for trainee firefighters and not a safety measure), German fire services measured blood pressure and pulse rate after every exercise, whilst Austrian fire services occasionally recorded the blood pressure of trainees. The mental impact of the training exercises upon trainee firefighters was measured in the Netherlands, but again this was not on a regular basis and it has not been stated how this was carried out (Gravelling et al., 2001).

5.4.3.4 Recommendations

Air consumption

Previous research examining exercise in heat has suggested a link between increased temperatures, increased levels of thermal strain, and heat stress placed upon firefighters (Carter et al., 2008). However, this was not reflected in the air consumption of participants in this study, where participants in the live fire task used less air than in either of the previous two tasks. By correcting for the different times to complete the task by establishing air usage per minute, it was calculated that the use of a 300 bars cylinder provides 49 minutes duration of air to the wearer, through a theoretical usage of 6.1 bars per minute (bar/min) within the SCBA set.

Air usage in this study varied across the different tasks, with the air used by participants in the guideline task calculated at 7.6 bar/min (as a result of participants using 107 bars for 14 minutes) likely to be expired after 39.5 minutes, and the air expiring in a search and rescue task expiring after 40 minutes if the participants' consumption of 7.5 bar/min was maintained. In contrast, firefighters calculated as using 5.5 bar/min in the live firefighting task actually had a slightly longer duration of air available (54.5 minutes) than predicted by theoretical usage of 49 minutes. Previous research has recognised that when wearing breathing apparatus the actual duration for work whilst wearing SCBA could be considerably less than the nominal values and time for safe exit is limited after the low alarm sounds (Bernzweig, 2004), and cylinders generally usually have a useful realistic life of around 50% of the rated time (Johnson et al., 2004), although to date there is no research that suggests the opposite may be true.

The findings of air consumption used by participants reinforce the essential use of a staffed entry control board by a dedicated entry control officer (ECO), the recommendation that firefighters must continuously monitor their air supply, and that in the event of a failure of each of these firefighters should immediately exit any irrespirable atmosphere. The theoretical duration of 49 minutes of air available should not be used by incident commanders when assessing the safety of SCBA wearers inside a building by considering the amount of air they have available. However, due to the risk of serious injury or death of a firefighter making further progress into a structure due to their overestimation of air supply, it is recommended that the results from the live firefighting sample in this study are treated with extreme caution when calculating working durations and assuming the cylinder to contain longer durations than expected in a firefighting task. These recommendations are consistent with those of Williams-Bell et al. (2010) who also argue that incident commanders should not consider air cylinders by their duration only, as this is misleading and potentially dangerous. Instead they should designate cylinders by their nominal volume, and ensure a good working knowledge of maximum rates of air consumption (such as by % of air cylinder) for specific tasks to ensure that firefighters can safely exit irrespirable atmospheres before critical lack of air supply. In their study of firefighters they found that automatic low air warning whistles on SCBA sets were actuating in as short a time period as less than 10 minutes during arduous tasks, suggesting that firefighters must be allowed a safety margin that not only allows them to get out but also to account for unexpected emergencies and potential self-rescue.

Since air consumption is increased due to increased effort and workload (Bernzweig, 2004), it is possible that the firefighters undertaking live firefighting may have moved more slowly and methodically due to the increased risk of injury or burns, as well as being forced to move more slowly due to the additional demands of the heat and internal temperatures within the structure. However, with previous researchers establishing that emotions such as panic or anxiety can reduce the duration of the cylinder oxygen due to increased breathing and respiration taking place (Sendelbach, 2001), it is also possible that the increased air consumption was representative of increased anxiety at undertaking guideline and search and rescue tasks. For example, anecdotal evidence from the participants of this study have suggested that guideline incidents have very rarely been encountered at operational incidents, whilst search and rescue activities are often undertaken as an on-station training exercise and rarely encountered at operational incidents without fire being present. This is in contrast to live firefighting activities that have been stated (both anecdotally by the participants of this study and by the participants of chapter 3) as being a relatively common occurrence and a more familiar task. Therefore it is possible that air consumption represents the increased physiological response to the stress of undertaking relatively novel tasks. Because heart rate and blood pressure were measured pre and post task, it is unknown what changes were occurring during the task and if this is related to air consumption. Further research incorporating continual heart rate and blood pressure measurements throughout the task are recommended to validate this possible effect.

Education and stress exposure

Webb et al. (2011) state that due to the pervasiveness of acute stressors, especially within fields that deal with dual stressors, the ability of individuals to adapt to repeated acute stressors may provide important information regarding the body's ability to adapt to stress and the need for more effective stress management practices. One of the key aims for this study was to identify the specific demands of SCBA tasks likely to be encountered by both novice and experienced UK firefighters, and utilise the findings to inform firefighters as to the likely effects that may be expected, both physiologically and psychologically.

In terms of educational awareness a two stage approach is recommended: one for the individual who may be required to undertake the task and another for the person responsible for health and safety on the training ground and at operational incidents who should be able to recognise signs and symptoms of extreme fatigue in the individual. Marshall (2003) suggests that the individual firefighter has a responsibility to recognise signs and symptoms in themselves that may pose a danger to themselves, including dizziness, blurred vision, muscle cramps, chest pain or excessive shortness of breath, which would indicate they had reached their maximum output potential and were in need of recovery. The person in charge of safety, or within the environment to recognise potential hazards in others, should be aware of external signs of extreme fatigue including how the person is moving, how they carry their body, body posturing, and changes in responsiveness to commands such as sluggishness or confusion. All of these symptoms could indicate near exhaustion and the potential for that individual to become a casualty, and therefore the escorted removal of the individual from the scene is the recommended approach (Marshall, 2003).

In particular, the findings of phase one demonstrated that novice firefighters reported a significant decrease in levels of alertness after completing a live fire task, despite not being at maximal levels of heart rate or at hypertensive blood pressure levels. Consequently, future research is recommended to identify the factors that may contribute to reduced alertness. This would allow firefighters, entry control officers, training officers, and incident commanders to be able make an informed decision on whether a firefighter is capable of redeployment in SCBA. Such recommendations are consistent with Hancock and Vasmatzidis (1998) who argue that because of the importance of mental performance, SCBA exposure criteria should be set on the basis of unimpaired mental task performance that would result in even lower working durations than those based upon physical measurements such as air consumption.

Phase two of this study indicates that in order to create an environment of high physical, mental and temporal demands, live fire conditions do not necessarily have to be present, offering support for on station training (in the firehouses) or at locations where live fire conditions are either too costly or unsuitable. This can involve the use of obscuration over the SCBA mask to simulate heavy smoke conditions. It is possible that a number of key skills requiring the recognition and management of the demands of one of the three SCBA tasks studies in phase two are likely to be utilised in another scenario, and as such training should be tailored around inducing high demand and not just a low intensity task based upon technical work.

The results of this study demonstrate that both novice and experienced firefighters will experience a significant cardiovascular response during live fire conditions, whilst phase two demonstrated that even in the absence of live fire conditions, SCBA training under ambient and cool training is sufficient to produce cardiovascular responses and high levels of demand even in tasks of less than 20 minutes duration. The physiological impact of the relatively short duration of the tasks in this study in both phase one and phase two, makes an argument against the introduction of extended duration SCBA (EDBA) that allows SCBA air duration to last continuously for up to 120 minutes. Others, such as Williams-Bell et al. (2010) support this view. They suggest that due to the extremely strenuous nature of firefighting found after only a brief task, any attempts to make firefighters work longer by supplying larger SCBA cylinders will simply result in greater levels of fatigue from which it would be extremely difficult to recover. Instead they recommend that firefighters at the emergency scene work in relatively short periods to decrease the likelihood of injury associated with greater fatigue.

5.5 Conclusion

This research considered the demands of SCBA during training exercises utilising a range of psychological and physiological measures. Phase one found that a single live fire task is capable of producing significant increases in heart rates in both experienced and novice firefighters, whilst the task will also lead to a significant decrease in the self-reported levels of alertness of novice firefighters. In phase two, there were little to no differences observed between the demands of guideline, search and rescue and live firefighting exercises.

Further research is required to identify the blood pressure reactivity of firefighters to SCBA tasks, as well as the potential influence of rest period, cooling and hydration status upon psychological and physiological responses. In addition, research is recommended to understand the demands of wearing SCBA at real-life incidents to allow training environments to replicate these demands an increase the transfer of learning of firefighters.

Wherever possible, training officers should consider the use of a range of physiological measures and self-reported psychological measures to validate the effectiveness of training activities and ensure that firefighters be given the opportunity to train in conditions of high physical and mental demands. This will also have the benefit of increasing an individual's own self-awareness and self-monitoring skills which were previously identified in chapter 3. Increased education for firefighters, training officers, entry control officers, and incident commanders is recommended to understand the likely demands of SCBA tasks, and identify potential decreases in the alertness levels of firefighters.

Chapter 6

Self-reported levels of anxiety, stress, and demand during the command and control of a simulated large-scale SCBA incident

"Firefighters often have problems with stress, fatigue, and mental overload. There is little training or advice given on how to mentally prepare oneself for what is ahead, how to avoid the impacts of fatigue, or how to mentally 'reload' during stress. Ways to mentally refresh have generally not been considered part of training…everyone from firefighters on up needed to be taught how to deal with large amounts of information in the field and how to recognise when critical pieces of information are missing, especially under stress."

Sharkey, Miller and Palmer (2011, p.7)

Chapter 6 – Self-reported levels of anxiety, stress and demand during the command and control of a simulated large-scale SCBA incident

6.1 Introduction

Chapters 3, 4, and 5 considered SCBA response in a range of tasks and from a cross section of experiences within the fire service, yet there is one aspect of SCBA that has been rarely considered in research despite the safety-critical components of the task; namely command and control. As well as undertaking specific SCBA tasks, the work performed by first responders including firefighters, police officers, paramedics and others in the emergency services will also involve the command and control of operational incidents. These will often occur under conditions of acute stress, with personnel responding to a scene having little or no knowledge about what they are to encounter. The environment will also be uncertain in terms of the condition and behaviour of those directly involved, the weather and terrain, and availability of resources (Regehr et al., 2008).

One of the key aspects of fire and rescue service (FRS) incident command and control is the ability of commanders and decision makers to think in a flexible manner and be able to critique a situation in order to identify any potential problems in the way the incident has been handled, and generate a set of alternative actions that anticipate novel or unusual events (Joung et al., 2006). However, incident commanders are not the only personnel involved in this process, and firefighters also have to make decisions continuously throughout an operation both in response to their commanders' orders but also in accordance with their individual competence and situational awareness.

To optimise life-saving achievement and damage mitigation, a firefighter's levels of competence must span from automatic, skill-based behaviour, to problem-solving, knowledge-based behaviour (Joung et al., 2006). Although the outlining of strategies and choosing tactics is mainly the responsibility of the incident commander, firefighters on scene may also have to choose tactics, and assume organisational and monitoring responsibility of other firefighters depending on their function and position during the emergency response within the other delegated roles (Sommer & Nja, 2011).

The firefighting scene requiring command and control will typically be a large incident. Such occurrences are described by the UK Fire Service Incident Management Handbook (IMH) (2008) to include the consideration of five characteristics common to all critical incidents that must be attended to by personnel:

i. Time sensitivity / tempo of activity: The time pressure required to make decisions and act upon them is a key factor in determining how severe an incident is, and will further drive the tempo of activity at the incident.
ii. Complexity: Incidents considered to be of a critical nature typically include a higher degree of complexity correlated with scale and uncertainty over outcome.
iii. Moral pressure: Varying degrees of moral pressure on those required to take action will exist depending upon the people and / or significance being put at risk.
iv. Duty of care: Linked to moral pressure, duty of care is the requirement of those in command to avoid unnecessary exposure to risk of those under their command at critical incidents.
v. Retrospective scrutiny: The requirement of those in positions of command and authority at critical incidents to have their decisions and actions publicly scrutinised in line with current litigation and legal accountability

As a result, the command and control of large scale incidents will utilise a wide range of roles, with everyone from firefighters up to the overall incident commander contributing to the incident. What the IMH acknowledges is that there will be a large number of characteristics that will be present at incidents and that the nominated individual must be able to identify and manage the demands of these characteristics. This study will seek to apply the principles of large incident commands and control to SCBA specific incidents to consider the stressors, dedicated roles and provide a rationale for research.

6.1.1 Incident command at SCBA-specific incidents

The command and control of operational incidents by all personnel at the scene is a key element of the emergency services ability to attend to and deal with a wide range of operational incidents, from relatively minor events to large scale, multi-agency disasters. Typically the main focus in the management of emergencies has been on resources and logistics requested by commanders, such as establishing *what* and *who* is needed, as well as *where* and *when* it is needed. The necessary resources include an emergency management plan and knowledgeable and decisive leaders (Kowalski, 1995). Joung et al. (2006) suggest that the those in command and control roles need to combine the ability to rapidly size up the situation and make a decision with the ability to think and behave as though the unexpected will happen. The ability of firefighters to undertake command and control duties is a mandatory component of their operational response, with Sharkey, Miller and Palmer (2011) suggesting that if firefighters are to continue working in incident management they will need to improve their ability to deal with the stresses of the job, including being able to maintain operational effectiveness, and avoid some of the negative effects that may lead to adverse decision making in field command roles. As such, any training that enhances the ability for incident commanders and those on the scene to identify a range of problems as possible actions before acting is important.

It is acknowledged that firefighters on the emergency scene who take additional time to find an optimal solution to an operational demand stressor run the risk of stalling their decision making, and therefore the aim is to find a satisfactory, workable course of action in response to the incident-related stressors (Flin, 2008). Further negative effects have been found in related fields that have examined individual responses to stress. This has included submarine commanders demonstrating a ‘fight, flight, or freeze’ response, increases in tunnel vision, misdirected aggression, denial of the magnitude of a problem, an inability to prioritise tasks, and ‘butterfly syndrome’ (flitting from one part of the problem to another without a solution or priority to the problem) (Charlton, 1992). Other studies have identified stress responses in individuals that have led to reduced concentration, narrowing of perception, an inability to perceive simultaneous problems, increased distraction, difficulty in prioritising, and distorted time perception in command roles (Weiseath, 1987). The presence of any of these effects that have previously been identified by Charlton (1992) that firefighters at an incident could lead to reduced performance and potentially put themselves and others at risk, and reinforces the importance of understanding the stress responses of personnel involved in the command and control of SCBA incidents.

Degradations in cognitive abilities have been extensively studied by the military during sustained operations, with Lieberman et al. (2005) identifying that those who are well trained typically seem to perform better under stress. However, the researchers also state that even well-trained leaders may exhibit significant degradation in cognitive performance and mood when exposed to severe, multifactorial stress, and that both military and civilian leaders need to plan accordingly for any rapid deterioration in cognitive function that may occur during extreme stress. Regehr et al. (2008) considered the question of whether stress affects performance in emergency personnel engaged in acute high stress situations. They conclude that a growing body of literature suggests that stress can lead to performance deficits, although it is unclear as to the impact of this stress upon the work of emergency workers performing critical functions. Further research has also found that stress may hinder the performance of individuals in some circumstances, yet facilitate it in others. For example, a study of paramedics by LeBlanc et al. (2005) found that following exposure to challenging simulated scenarios, 60% of participants demonstrated performance degradations in their ability to perform drug dosage calculations, 20% showed no change in performance and 20% showed an increase in performance.

6.1.2 Four roles operating at ‘bronze’ command level

Previous research and attitudes of effective leadership in both military combat and firefighting situations advocated that the leader who sets an example through personal risk taking will be judged by their staff to be the most effective (Frost et al., 1983). However, priority is now of crew safety at the scene ahead of risk taking, which can be achieved through the implementation of a model known in the UK as the incident command system. A related model also exists in the USA and is considered the dominant regulatory system for all US firefighting organisations, and a requirement for a broad array of emergency responses (Kunadharaju et al., 2011).

The levels of command control and managerial control required at an incident will lead to the allocation of a command level as either gold / strategic, silver / tactical, or bronze / operational levels (Arbuthnot, 2008). Of most relevance to this study is the ‘bronze’ level of command and control, considered to be the ‘hands-on’ area involving task level work for both the fire service personnel involved at the scene, and the sector commanders who co-ordinate these activities. This will also involve working to a time scale that can often be measured in minutes as opposed to the days or hours that may be found at the upper tiers of gold or silver command (Arbuthnot, 2008).

The bronze level of command is characterised by having no warning of the incident (i.e. will involve the personnel being dispatched from their fire station), and as such the bronze incident commander will typically be the first commander on the scene. There will also be additional support provided by a number of key allocated roles that are assigned to personnel arriving as determined by the incident command system doctrine depending upon the scene. These additional roles may include an incident commander, sector commander, command support officer, and on all occasions requiring SCBA to be worn, a dedicated entry control officer. The key characteristics of each role will be discussed below.

6.1.2.1 The incident commander

The incident commander (IC) (also known as the officer-in-charge or OiC) at an incident is the 'nominated competent person' usually identified through wearing of a white tabard worn over the firefighting tunic. Whilst this role does not need to be filled by the most senior officer present, often the most senior officer present does have a moral and organisational responsibility within the overall incident command structure that cannot be divested. The incident commander will remain in charge of the overall management of the incident at all times. They will focus upon the command and control of the overall incident, deployment and requests for additional resources, tactical and planning co-ordination of the sector operations, and the management of the incident itself.

6.1.2.2 The sector commander

If or when the demands of the incident placed on the IC are so great as to make it important to delegate responsibility and authority to ensure that appropriate command and safety monitoring of all activities takes place, and to prevent any reduction in fireground performance, sectorisation will be introduced. This involves the incident being 'broken down' and split into smaller segments each managed by a dedicated sector commander.

The sector commander is in direct contact with the personnel in their sector, and needs to provide direct and visible leadership at each sector, whilst remaining directly accessible to the incident commanders for whom they are responsible. The sector commander takes responsibility for the resources within that sector, focusing upon command and control, deployment of resources, tactical planning, SCBA search co-ordination, and the health and safety of personnel within the sector. The individual in this role can be considered to have a high degree of operational independence in determining how objectives agreed with the IC are to be delivered. Psychologically, one of the key roles for the sector commander is the requirement to motivate and control personnel and crews who are undertaking difficult, dangerous and sometimes distressing work, as well as having to make rapid decisions and ongoing appraisals in a narrow timescale

6.1.2.3 The command support officer

Command support is recommended by the incident command system to be introduced at all incidents to assist the IC with the management of the scene, and should be introduced as soon as possible from arrival at the incident to assist with the management of the scene. The key duties of a command support officer on the scene include the first point of contact for attending appliances and officers to maintain a record of attendance, allocation of fire ground radio channels and to log relevant data, and maintaining a record of operational decisions made or actions taken as result of it. The command support officer will also be required to record the relevant information about the sectors in operation (such as names, identification of the sector, physical boundaries, and resources deployed in that area).

6.1.2.4 The entry control officer (ECO)

In the UK, procedures dictate that operational firefighters do not ‘self-deploy’ themselves into operational incidents, but instead follow a pre-determined hierarchical structure that first establishes the need for SCBA to be worn by personnel at the incident to ensure the successful control of fire and rescue of life. As soon as possible after the IC makes the decision to use SCBA, control procedures are set up sufficient to monitor the risk to the safety of SCBA wearers, namely through the allocation of an entry control officer (ECO).

The ECO is responsible for the monitoring of all personnel deployed into the risk area in SCBA through the establishment of a designated entry control point (ECP) made aware to all relevant personnel, and correct usage of an entry control board. Technical Bulletin 1/1997 (Communities and Local Government, 1997) identifies that once designated by the IC, the ECO shall don the appropriate tabard and undertake a number of key duties. These include the briefing of SCBA wearers prior to entry into the risk area, maintaining radio communications with the SCBA team or team leader, and receiving the identification tallies (containing the name of the wearer and cylinder at time of entry into the risk area) of the wearers and calculating the emergency time of whistle (the time SCBA wearers should exit the building) for each wearer (using time of exit using a working duration table added to the SCBA wearers time of entry). The ECO is also required to indicate the location of the SCBA wears on the entry control board and is responsible for keeping the IC informed of all relevant developments or requirements related to the wearing of SCBA using information gathered from the SCBA wearers at the incident.

6.1.3 Incident command training implications

The infrequent nature of large-scale disasters during a firefighter's career often means that such personnel will often have limited experience of the demands of real-life incidents. This reduction in the collective experience of emergency personnel is also attributed to a lack of available practice opportunities to experience the chaos of large incidents, make mistakes, have the mistakes identified, and then go through the scenario again (Danielson & Ohlsson, 1999). As a result, some firefighters are rising to higher ranks without a vast amount of major incident experience, creating problems for the acquisition of skills at large and novel incidents, and possibly leading to a potential risk to life on the emergency scene.

One of the traditional methods of undertaking large scale incident command and control training is through large scale activities run in real-time. However, realism and fidelity are usually difficult to achieve in these tasks, and the active participants in the drill are usually only in attendance for a few hours. Due to risk of damage and high costs, fire services may not be able to justify the use of live fire conditions outside of the purpose built (and fire resistant) structures used at their training schools, limiting larger scale scenarios within stadium, ship, or large factory locations, although smoke generators and actors as casualties can and have previously been employed in locations external to the FRS training environment.

Within these large scale scenarios, there will often be limited opportunities for any repetitive skill rehearsal for an individual, as well as a lack of chances for other personnel in the same role to take charge due to being on a different shift, sick leave, or due to undertaking different duties during the task (Wilkerson et al., 2008). Large-scale exercises are typically expensive, often costing hundreds of thousands of pounds, and require the attendance of gold or silver commanders as well as other agencies. As a result, personnel in command and control roles may be unwilling to make mistakes or try alternative methods in the optimal environment, thus limiting the effectiveness and benefits of training. Furthermore, there is the risk of expensive full-scale exercises being heavily scripted to guide the exercise to a desired outcome of the planning organisation. Finally, Wilkerson et al. (2008) also describe how individual feedback following the task is often slow, with post task reports taking months to prepare and often broad reports covering procedures and not specific individuals who may benefit most from the feedback. Personnel who may have benefited from observing other roles in action may find themselves hundreds of yards away from the action and even unable to gain any benefit from this. Furthermore, given their infrequency, these types of incidents are often complex, initially chaotic, and challenging to manage, and as such there remains a risk (both to themselves and personnel under their command) of exposing inexperienced officers to this environment (Crego, 2007).

On a smaller scale, the use of ‘tabletop’ exercises is common practice in emergency services. In these tasks, participants discuss desired responses to a predetermined scenario controlled by a moderator, and provide a useful alternative due to their lower cost and increased frequency and standardisation of the scene. However, again there is problem with realism and skill of the moderator, and such exercises can be limited by factors such as resource allocation that includes unrealistic response times and equipment and personnel availability. Post incident evaluations are heavily dependent upon the evaluator’s ability to accurately capture the events of the exercise through observation (McGrarth & McCarthy, 2008).

The adopted solution to these problems is the development of an immersive, computer based learning system. Webb et al. (2010) have suggested that the unique occupational demands of firefighting are difficult to replicate in a laboratory situation, and as such the use of computer scenarios has become more prevalent in fire training as they allow for the manipulation of predictability and require fire and rescue personnel to respond to challenges similar to those presented at a fire scene, but in an environment that poses less physical risk.

Outside of the UK, The United States Fire Academy (USFA) and other fire departments are now using computer scenarios to assist in the development of incident command strategies in order to meet training objectives for fire and other emergency personnel (i.e. Webb et al., 2011). For example, Wilkerson et al. (2008) utilised a virtual reality environment (CAVE) to model a terrorist explosion resulting in a mass casualty incident. CAVE provided the illusion of immersion by projecting stereo images onto the walls and floor of a cube based room that includes unrestricted navigation, interaction with virtual objects and physical objects placed in the environment, and enhancement through directional sound. This allowed for multiple personnel to undertake the same task under standardised conditions. Such methods are also commonplace in military training sectors. For example, currently all U.S. military flight training incorporates simulator training into its syllabus to some extent (Koonce & Bramble, 1998), whilst a review of 247 flight simulator studies by Hays et al. (1992) found that 90% of their reviewed studies favoured flight training combined with simulator training to flight training alone.

6.1.3.1 Minerva

One example of immersive learning within the UK emergency services is a computer simulation system developed by the London Metropolitan Police, known as the ‘Minerva’ system (Crego, 2007). This programme allows personnel to train in the command of realistic and real-time environments associated with major emergencies such as plane and train crashes, major fires and terrorist attacks. By making the command training computer based, officers within ‘Minerva’ are able to try out their skills, solve command problems and overcome the challenges of these events, whilst making use of communication tactics and deployment of resources that can be easily observed by trained facilitators. As there are no operational consequences for mistakes, officers are able to take charge of large scale critical incident command that allows for identification of good and bad practices, and for experience to be gained in team based or coordinated approaches with other incident commanders.

Due to the immersive nature of the programme, situations are designed to mirror conditions that commanders would reasonably be expected to be confronted with and features problems built into the scenarios. Therefore, any students who fail to take control of and resolve the unfolding situation find that the problems are compounded and the situation worsens. Crego (2007) suggests that it is this realism within the training setting that ensures the experience gained by participants can be readily and easily transferred to live incidents and events. Specific situations and scenarios built into the system are designed and developed by staff at each specific fire service site depending upon the specific demands for that organisation and area, ensuring increased levels of realism and relevance for their staff taking part.

6.1.4 The importance of incident command

The importance of understanding the incident command demands and stressors perceived by those on emergency scene cannot be underestimated, despite the current lack of FRS research examining the potential affects. McGrath and McCarthy (2008), when describing incident command exercises in Police and Homeland Security Departments, suggest that incident command requires practice in procedures, communication, leadership, and the ability to develop situational awareness from sometimes ambiguous and incomplete information. Only repeated rehearsal of incident command roles and responsibilities under simulated crisis conditions is considered to be able to mitigate the potential degradation of decision-making skills under stress.

In the US, Kunadharaju et al. (2011) analysed the 664 firefighter fatalities that occurred between 2004 and 2009, and reported the National Institute for Occupation Health and Safety (NIOSH) investigations of 189 fatality investigations involving 213 line of duty deaths, and found that almost half of all the recommendations resulting from trauma-related fatality investigations involved some aspect of planning or incident command. A total of 1,167 recommendations arising from the investigations were narrowed down into 35 high frequency recommendations within a further eight content domains. Planning and incident command contained 10 high frequency recommendations (i.e. cited 7 times or more during investigations), including 'pre-incident planning and tactics' to 'personal accountability and 'rescue'. The most frequently cited recommendation was the role of an incident commander to 'size-up' the incident and continuously evaluate the risk versus benefit during the entire scene of operations. Four of the high frequency recommendations involved staffing directly, including maintaining someone in the incident command role at all times, adequate staff to respond to emergencies, rescue team readiness and availability, and a designated safety officer in place. The application of these recommendations to working practices within command must be further understood regarding the performance and stress it places upon individuals to ensure that similar levels of fatalities do not continue.

6.1.5 Aims of chapter 6

As identified in previous chapters, the majority of tasks faced by firefighters are characterised by high physical demand involving complex and rapid decision making under intense time restraints. Incident command is one area of the fire service that is in contrast to this, instead involving decision making and scene management under high temporal demands but limited physical demand within a SCBA incident.

At present, few studies have investigated the issue of stress reactivity of fire service command and control roles at large scale SCBA incidents. When describing the current state of psychology-related research to fire service command, Flin (2008) states how traditional decision-making literature is derived from the disciplines of management, statistics and economics, and therefore offers very little relevance to the fire service incident commander. This decision-making research is rarely concerned with the dynamic situations, life threatening odds or high time pressure, that are all key features of an emergency. Instead, business management research is concerned with individuals making strategic decisions when they have several hours or days to think about the options, instead of the seconds in firefighting. Finally, Flin (2008) suggests that even if psychology literature is considered, current research will provide limited application to emergency decision making, as so much of it is based on undergraduates performing trivial tasks in laboratories.

This is not a research gap limited to the fire service, with a study of military leaders also emphasising the lack of training specifically geared for leaders to address operational stress issues (Adler et al., 2008). Future research is unable consider the impact of stress upon the performance of fire and rescue personnel in command and control roles without first establishing if such stress reactivity to these roles exist and the extent to which this may occur. Therefore there were three aims to this study:

i. Identify and determine the demands of a simulated SCBA command and control exercise.
ii. Identify the specific demands of four command and control roles undertaken during the exercise
iii. Assess changes in subjective measures of stress that occur as a result of participation in a simulated SCBA command and control exercise.

6.2 Method

6.2.1 Participants

A total of 80 male career firefighting personnel from the same fire and rescue service took part and were considered to be currently active operational personnel either in a firefighter (FF) (n = 60), crew manager (CM) (n= 14), or watch manager (WM) (n= 6) role. Participants were aged between 29.1 and 48.0 years (mean = 39.0 years) with years' service in their current role ranging from 10 months to 26 years (mean = 21.1 years). This was their first exposure to the incident command suite and the 'Minerva' exercise. Standard 'on-station' personal protective equipment (PPE) was worn, consisting of fire service issue trousers, safety shoes and short sleeve cotton shirt.

Eight participants were involved in each exercise at a time. Representative of a real incident this would consist of the personnel available on two fire appliances and was made up of a combination of an officer in charge, up to four entry control officers, one command support role, and up to four sector commanders. In total, this study featured the participation of ten incident commanders, ten command support officers, 30 sector commanders and 30 entry control officers during the task. Roles during the task were identified through the use of tabards worn by personnel, and are the same tabards carried on a fire appliance for use at operational incidents.

All personnel were members of the same duty watch and were on active duty that day. As a result personnel attended in fire appliances from their home station to the incident command suite. Since the incident command training forms a compulsory part of the development of operational personnel, this was training already programmed in by the participating fire and rescue service, and as such there were no exclusion criteria for this study.

6.2.2 Apparatus

6.2.2.1 Incident command suite

The incident command suite where all testing was conducted is a purpose built complex featuring a large lecture room, a control room, and four separate rooms along a single corridor designated as 'sectors' denoted by colour (red, blue, green, or yellow) identified at the site by the colour of the door and carpet. Each room / sector was fitted with a large monitor displaying real time images of the side of the building that must be attended to, whilst two video cameras were linked to the control room to observe the crews undertaking the task. A one way microphone was set up in each room to allow the control room to listen to the conversations and decisions taking place. Other equipment in these rooms / sectors is representative of the equipment that would be available at a real life operational incident of this nature, including identification tabards, breathing apparatus entry control board, sector command board, white board, and radio's to allow communication with other sectors, breathing apparatus wearers and the officer in charge.

A central control room within the incident command suite allows the team of four facilitators to simultaneously observe all four sectors of the incident, and listen in to conversations between the participants, as well as listening in on all radio traffic on the different channels used.

6.2.2.2 Question Booklets

In order to capture as much information as possible in a limited time period, a paper based questionnaire booklet was incorporated for data collection. A copy of this questionnaire booklet can be found in appendix G.

Perceived workload

The National Aeronautics and Space Administration Task-Load index (NASA-TLX) (Hart & Staveland, 1988) was incorporated to measure the interaction of the participant with the task demands. This consists of six workload facets; mental demand, physical demand, temporal demand, effort, performance, and frustration along a visual analogue scale anchored from 'low' to 'high' relating to the subjects' experience of the test that had just been completed. The measurement scale was from 0-100, with a higher score indicating greater levels of the facet during the task.

State anxiety

State anxiety is described as the anxiety related to present circumstances (Storch & Panzarella, 1996), and is considered to be the most commonly used assessment of stress manipulations (Regehr et al., 2008) as well as being sensitive to acute stress manipulations (Spielberger, 1983) in emergency workers during simulated exercises (LeBlanc et al., 2005). A short form version of the Speilberger State-Trait Anxiety Inventory (STAI; Speilberger, 1983) by Marteau and Bekker (STAI-SF; 1992) was incorporated and modified into a 100 mm visual analogue scale to ensure consistency with the other state measurements. A six-item inventory, the STAI-SF offers a brief alternative to the original STAI and has a reported reliability coefficient of 0.82 (Marteau & Bekker, 1992).

Participants were asked to read each statement and mark how they felt at that exact moment, to give a score from 0-100, anchored by 'not at all' and 'very much'. Facets considered to be beneficial (calm, relaxed, and content) were negatively scored, and the scores of all six items added to give an overall score of between 0 and 600, where a higher score indicated higher levels of state anxiety.

Self-reported stress measures

In order to capture stress and happiness responses two questions were asked:

- 'I feel stressed'
- 'I feel happy'

To ensure continuity of participant responses, questions were placed on the same page as the state anxiety measure and scored the same way, with participants making how they felt at the that exact moment between a 100 mm visual scale anchored by 'not at all' to 'very much'. A single score was recorded for each of the two facets, with scores range from 0-100, whereby a higher score indicates a higher perceived level of that factor.

6.2.3 Procedure and task

Following approval from Northumbria University School of Life Sciences ethics committee, approval was sought also from a number of senior officers within the individual fire and rescue service including the senior training manager, brigade training centre manager, and the station manager in charge of the incident command suite.

Testing was conducted across ten separate days within a five month period (February – July 2011), with each participant taking part in the exercise once. All personnel taking part in that day's exercise started and completed the task at exactly the same time and thus completed the questionnaires at the same time as each other.

Upon arrival at the site participants were greeted, given an overview of the procedures to be followed, and asked to read the 'information for participants' booklet. At this point participants were given the opportunity to ask any questions and also an explanation of the information they would gain as a result of their participation in the study. If they were willing to take part, a consent form was read and signed.

As the data collection was taking advantage of mandatory watch skills maintenance training conducted on a bi-annual basis, participants were provided with a thorough exercise brief by the specialist incident command staff, before completing the first part of the booklet in the lecture room consisting of the demographic information; and the anxiety, stress and happiness measures.
To replicate the structure and ensure 'real-life' validity with operational incidents, a number of roles were integrated into the task. In total there were four main roles measured during each simulation:

1. Incident commander (IC)
2. Sector commander (SC)
3. Entry control officer (ECO)
4. Command support officer (CSO)

During the simulated activity personnel did not have to adhere to their role and therefore there were occasions where firefighters were able to assume the role of sector commanders, and for crew managers to take on the role of an incident commander. Roles were set by the commanding officer of the attending watch at the exercise and were not subject to any intervention by either the research team or incident command suite personnel. The 2008 UK Incident Management Handbook was utilised as the basis of operational procedures by participants.

Participants were 'turned out' to the incident from the upstairs lecture room representative of a real incident using a computer printout representative of a regular dispatch. No information was provided until arrival at the scene and participants were turned out in teams of four to represent a fire appliance. The scenario was of a large industrial unit well alight with persons reported to be trapped inside. On arrival crews would be faced with a visual display on each of the monitors of the outside the building with smoke billowing out, as well as a member of incident command suite staff playing the role of the fire warden of the building who could provide information if asked. This information included floor plans, building construction, and persons believed to be inside the building.

Although SCBA was not required to be worn by any personnel during the task, entry control officers could simulate the entry of firefighters through the use of an entry control board and pre-written SCBA tallies, and by maintaining radio communications with members of incident command suite staff in the control room who were simulating the role of the SCBA wearers and who tracked their progress using an interactive screen. During the exercise, all participants were free to move between the different rooms / sectors as required by the IC.

Possible considerations include the method of entry into the structure, number of firefighters committed to search for persons believed to be trapped inside, search pattern and the location of their entry, additional resources required and method of attack on the fire (offensive or defensive). Additional resources such as specialist fire appliances or external agencies (such as police or paramedics) could be requested but would be provided in token only (i.e. no additional personnel would appear at the incident), although such requests would be noted by incident command suite staff for use at the post task debrief.

The task was undertaken until the 'fire' was extinguished and objectives completed as dictated by a member of the incident command suite staff in the control room who displayed this via the TV screens in each sector screens. Upon immediate completion of the task participants returned to the lecture room and completed the remaining part of the question booklet. Participants were also required to state at the front of the booklet their primary role during the task, and given the opportunity to ask any questions or voice any concerns about the process. Finally, participants were thanked and provided with a participant debrief before taking part in a task and performance related debrief provided by incident command suite staff.

Of the 88 personnel who were approached to take part, 100% agreed to do so. Eight questionnaires belonging to the cohorts of one exercise were excluded after being turned out to a real emergency halfway through the task and not being able to fully complete the exercise. Data was discarded as only the pre-task data had been completed by this group.

6.2.4 Treatment of data

In order to assess the effect of role on NASA-TLX scores, following exploration of data, a series of one way ANOVAs were utilised. Mixed measure ANOVAs considering time and role, and role x pre-post interaction were employed. *F* and *P* values, and effect sizes are reported throughout and post-hoc analyses utilising Bonferroni tests were conducted when appropriate. An alpha level of .05 was employed to determine the significance of all statistical tests.

6.3 Results

6.3.1 Task demands

Participants completed the task on a single occasion, with the time taken to complete all aspects of the simulation taking an average of 47 minutes, although this ranged from between 39 to 55 minutes amongst the groups.

The role of the incident commander was considered by participants to be the most demanding role in terms of mental demand (m = 86), and temporal demand (m = 78), effort (m = 77). Command support officers reported the highest levels of physical demand (m = 21) and performance (m = 72); and sector commanders stated the highest levels of frustration (m = 37). Means and standard deviation scores of the six strands of perceived workload by the four task roles are displayed in table 6.1:

Table 6.1. Participant self-reported perceived workload means (and standard deviations) of each of the four task roles following completion of the incident command exercise as measured by the NASA-TLX (*n* = 80).

	NASA mental	**NASA physical**	**NASA temporal**	**NASA effort**	**NASA performance**	**NASA frustration**
Incident commander (IC)	86 (8)	18 (10)	78 (11)	77 (11)	67 (14)	37 (23)
Sector commander (SC)	65 (20)	21 (20)	57 (21)	58 (21)	64 (25)	37 (25)
Entry control officer (ECO)	63 (22)	17 (25)	46 (29)	56 (27)	64 (24)	37 (27)
Command support officer (CSO)	61 (31)	21 (21)	52 (29)	60 (28)	72 (14)	29 (31)

Analysis found that there was a statistically significant effect of role during task on mental demand (F (3, 76) = 3.069, $p = 0.033$) and on temporal demand and role (F (3, 76) = 4.306, $p = 0.007$). No significant main effect was found upon levels of physical demand ($p = 0.912$), effort ($p = 0.132$), performance ($p = 0.774$), or frustration ($p = 0.862$).

There were significant differences found between the mental demand of the incident commander and entry control officer roles (p = 0.034), and also significant difference found, between the temporal demands of the task when in the roles of incident commander and entry control officer (p = 0.004). There were no other significant differences between roles reported

6.3.2 Psychological stress

Means and standard deviations for the three self-reported measures of the mood and stress measures are displayed in table 6.2.

Table 6.2. Means (and standard deviations) of task induced changes in the four participant roles as measured by state anxiety (as measured by the STAI-SF), and self-reported measures of stress and happiness following completion of a simulated incident command task (n = 80)

	Happiness		**Stress**		**State anxiety**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Incident commander (IC)	68 (12)	60 (12)	34 (16)	40 (24)	168 (81)	199 (101)
Sector commander (SC)	75 (19)	79 (18)	17 (20)	22 (19)	142 (93)	143 (86)
Entry control officer (ECO)	74 (18)	64 (33)	12 (24)	26 (34)	127 (73)	186 (141)
Command support officer (CSO)	64 (25)	81 (8)	28 (24)	15 (9)	135 (103)	100 (58)

6.3.2.1 Anxiety

The role of the incident commander reported the greatest levels both pre (m = 168) and post (m = 199) task levels of anxiety, demonstrating an increase that was also demonstrated by the entry control officer pre (m = 127) and post (m = 186) task. Self-rated means of the sector commander remained relatively stable pre (m = 141) and post (m = 143) task, whilst command support officers reported a decrease in levels pre (m = 135) and post (m = 100) task.

There was no significant effect of time on the levels of anxiety (F (1, 76), = 0.946, p = 0.334, partial n^2 = 0.012), of task role (F (3, 76), = 1.263, p = 0.293, partial $n^2 = 0.047$) or a significant interaction between anxiety scores and task role (F (3, 76), = 2.30, $p = 0.084$, partial $n^2 = 0.083$).

6.3.2.2 Stress

Levels of stress increased for the incident commander pre (m = 34) and post (m = 40) task as well as for the entry control officer pre (m = 12) and post (m = 18) task. The command support officers reported decreased levels of stress (pre m = 28; post m = 15) post task, whilst the sector commanders demonstrated a slight increase in pre and post task self-reported levels of stress.

There was no significant main effect of pre-post changes in stress levels (F (1, 76), = 0.898, $p = 0.346$, partial $n^2 = 0.012$), although there was found to be a significant effect of task role (F (3, 76), = 2.808 $p = 0.045$, partial $n^2 = 0.100$), and a significant interaction between pre-post levels of stress and role during the task (F (3, 76), = 2.871, $p = 0.042$, partial $n^2 = 0.102$). Post hoc analysis demonstrated a significant difference between the incident commander and entry control officer ($p = 0.042$) levels, although no other significant differences were found.

6.3.2.3 Happiness

There were post task increases in both the sector commanders (pre m = 74; post m = 79) and command support officers (pre m = 64; post m = 81) whilst both incident commanders and entry control officers demonstrated decreased mean scores during this period, as displayed in table 6.2.

There was no significant effect of time upon levels of happiness (F (1, 76), = 0.105, $p = 0.747$, partial $n^2 = 0.001$), and no significant effect of task role (F (3, 76 = 1.817, $p = 0.151$, partial $n^2 = 0.067$) despite a significant interaction between pre-post changes in happiness and role during task (F (3, 76), = 3.139, $p = 0.030$, partial $n^2 = 0.110$). Bonferroni post hoc analysis did not find any significant differences between any task roles.

6.4 Discussion

Expert performance under extreme stress in the fire service is considered to exist as a result of extensive exposure and experience at previous incidents. This is considered to equip the individual with the ability to then engage in mental simulation of events to make the appropriate decisions. These skills are considered to be less developed in inexperienced firefighters who do not have the experiences to draw from when assuming a command role (Danielson & Ohlsson, 1999). A theoretical knowledge is often insufficient to meet this experience gap, with previous research identifying that although personnel trained in incident command know what should be done, and can readily identify appropriate actions in a classroom or other relatively less stressful exercise, once immersed in the chaos of a high-fidelity disaster scenario, these errors are again found to be committed (Wilkerson et al., 2008). As such, experience is hoped to be gained from an interactive, immersive training environment that should replicate stress likely to be found at an operational incident.

The structure of command and control by the UK fire and rescue service at large scale incidents use a series of guidelines that place operational personnel within a clearly defined structure and provides roles that encompass all personnel dispatched to the incident. The importance cannot be underestimated since this incident is likely to be considered as inherently unpredictable, volatile, and fraught with risk, requiring the commanders to make decisions under uncertain information and limited resources, and to think and behave as if the unexpected may happen, often at incidents that cannot be covered by standard operating procedures (Joung et al., 2006). As such, an increased understanding of the role specific demands placed on an individual in a particular role, as well as the incident influence upon anxiety and stress levels is critical to the safety of themselves and the public involved.

This study found that a large amount of effort was required to meet the demands of the task, characterised by significant levels of mental and temporal demand. Results were comparable with Webb et al. (2011) who found average NASA-TLX workload levels of 68.75 when participants were faced with a computerised fire suppression simulation. Mental demands and temporal task demands reported by the personnel allocated as incident commanders in this study were found to be significantly greater than entry control officers, with the IC’s also self-reporting the highest levels of each of the facets of mental demand, temporal demand, effort and performance.

The simulated task was not found to lead to a significant change in self-reported levels of state anxiety, or significant differences between roles. Previous research such as Neil et al. (2011) has identified that in sports participants under stress, anxiety experienced was due to appraisals by the sports participants themselves such as uncertainty and threat relevant to performance, and therefore it is possible that such effects were present in each of the roles.

The current results demonstrated that of the four roles, incident commanders started and finished the task with the highest levels of state anxiety, although both levels could be considered to be relatively low levels below 200, against the potential maximum score of 600. This increase was also found in the entry control officers, whilst sector commander scores remained stable pre and post task, and the command support officers demonstrated a decrease in mean state anxiety score.

In the measure of stress, although overall means stress levels reported by the four roles were all comparatively low both pre and post task, only the incident commanders reported significant changes, including post task stress levels increasing significantly higher than by the entry control officers. No other significant differences were found although mean scores demonstrated that command support was the only role to decrease in levels post task, whilst the sector commander stress levels were found to remain relatively stable. Finally, the measure of happiness demonstrated no significant differences between task roles.

6.4.1 Role demands

The results suggest that the most demanding and stressful role undertaken at a large scale SCBA incident is that of the incident commander, which would be expected due to the responsibility as one of overall command and control of the incident which becomes even more complex with increased scale and duration. The IC's are likely to be the most senior person at the incident, receive training specific to the role, and as they are likely to be the first arriving crew commander, they would be primarily concerned with the tactics and operational tasks in the initial stages of the scene of operations. This would include requesting further personnel and resources, and 'sizing-up' the scene to assess the risk to firefighters, and the likely development of the internal and external conditions.

Langerman (2007) suggested that a major task for those in the incident commander leadership role is to see and manage the most significant aspects of the whole incident, including the identification of 'critical aspects' which, if properly controlled will result in a positive outcome. This will also include keeping sight of the 'big-picture', regardless of the size of the incident, and preventing themselves from micro-managing by focusing upon single issues or sectors and not allowing staff to do their jobs. This is in contrast to the other three roles within the task, who are delegated a specific set of objectives to complete that contribute to the overall management of the task. Staff within these supporting roles do not have to consider the cumulative effect of these objectives upon other tasks on-going elsewhere at the incident due overseeing only a relatively small segment of the incident. Despite increases in state anxiety and stress similar to the incident commander, the finding that entry control officers reported significantly lower temporal and mental demands than the incident commanders was also expected, despite the entry control officers being theoretically directly responsible for the monitoring and welfare of the most personnel during this task (up to eight SCBA wearers, and an emergency team of two SCBA wearers can be monitored on an entry control board at any one time).

As discussed in the introduction, one of the key aims of participants taking part in this task was to gain experience of the demands of being involved in a large scale incident that may not occur on a daily basis, and when the creation of such incidents as a real life scenario is likely to be prohibitively expensive and/or dangerous. Entry control however, is a mandatory aspect of breathing apparatus control procedures and is utilised in almost all SCBA activities, including those conducted on station. The personnel in this study are likely to have extensive experience of the duties of an entry control officer, and even if they had yet to be allocated that task at an operational incident, have a mandatory requirement to use and record usage of the entry control board in a training environment every three months. Furthermore, even the mental demands of the task, such as the manual calculation of each wearers breathing apparatus cylinder and time their emergency whistle (Technical Bulletin 1/1997), could be offset by familiarisation and experience operating as an entry control officer (Sommer & Nja, 2011).

Sector commanders can be considered as undertaking many of the same tasks as the incident commander (for example coordinating rescue resources, containing fire spread, and fire extinguishment) during the incident but on a smaller scale and with the incident commander overseeing them to liaise with and obtain explicit approval before affecting any changes (Incident Management Handbook, 2008). Within the four roles of this particular task, sector commanders represented the greatest responsibility that can be placed upon an individual without specific incident management training (such as firefighters), but is also a role that can be undertaken by those with incident command experience such as crew managers who act as the ‘second in command’ for an operational watch and act up to the role of watch manager when required. It is extremely unlikely that a firefighter would be required to act as an incident commander at an operational incident; instead the incident commander would request more appliances if additional trained commanders were required. Therefore these two groups (experienced vs. inexperienced; firefighter vs. crew manager) may simply have cancelled each other out, whereby inexperienced firefighters increased in stress and anxiety through little prior experience of the role, whilst experienced crew managers showed a decrease in anxiety post task due to limited amounts of responsibility required. Certainly, the issue of current occupational rank and its effect upon incident command role is an interesting point worth future investigation.

Finally, command support officers, by definition, are in a supporting role, primarily involved with the monitoring of attending appliances and officers, as well as the recording of tactical decisions in sectors. As a result, this role involves undertaking tasks under time pressures that will exist upon arrival at the incident and during the initial stages of the incident, and therefore involve receiving large quantities of information (primarily verbal over a single handheld radio channel) from all of the sector commanders and ensuring that this information it is correctly disseminated. Levels of anxiety and stress occur as a result of the unknown demands of the task prior to deployment (such as incomplete information), and are unlikely to exist towards the end of the task since all duties have been undertaken. Whilst carrying out an essential aspect of the command and control of an incident, the command support officer does not have to make any tactical or operational decisions, nor are they directly responsible for the safety and welfare of other firefighting personnel. Due to recording of information and updates in each sector, they are also provided with an overview and running commentary of exactly what is happening at each sector of the incident, and therefore will be aware of a successful outcome (and corresponding increases in level of happiness). Such information will not be available to sector commanders who have only information on their sector available, or the IC, who knows that all decisions will be discussed during the incident debrief and feedback session with the incident command suite staff, and this may account for the post task decreases in stress and anxiety levels from the command support officers.

It is assumed from previous researchers that the stress and demand of the SCBA command and control task used in this study arises from its novelty and the inexperience of the sample in this simulated environment (Danielson & Ohlsson, 1999). Therefore, it is expected that through repeated exposure to such demands, decreased individual stress responses should result due to mastery or experience of the task. Although a wide range of operational experience was reported by participants (from 10 months service up to 26 years full time duty), the mean score was reported as around 21 years' service, suggesting the participants were experienced firefighters and as such their past experiences of high stress environments may have attenuated state anxiety and perceived exertion when performing these simulated command operations, as found in previous research (Hytten & Hasle, 1989). It is unknown if this is the case and any further studies should assess the effects of repeated incident command simulations, preferably with switching of allocated roles to gain experience of all potential physiological and psychological demands that may arise when asked to assume that role at a real incident. Such practices are common in the military, where a leader must understand the duties and functions of each job under their command, and as a result young officers in the military are rotated through many jobs during their growth to ensure that the aspiring leader is completely familiar with every task (Langerman, 2007).

6.4.2 Methodological considerations

This study was the first to examine the role specific demands of large scale firefighting activities. As a result, a number of methodological factors have been identified relating to the nature of the task and performance measurement considerations that need to be addressed if related research is to be undertaken.

6.4.2.1 Task

The use of simulation is considered an acceptable tool to assess incident command and control (Joung et al., 2006). However, one of the main benefits of the 'Minerva' simulation system, the ability to create risks and scenarios that are representative of that geographical location, could also be considered a limitation of the study. Developed by an in-house software developer employed by the participating fire and rescue service, the scenario faced (large factory unit with persons reported), was representative of a challenge likely to be faced in that fire service area. All participants in this study were employees of the same large, urban metropolitan fire and rescue service with a large number of industrial and manufacturing risks. As a result, it would be unwise to generalise the results to other fire services that are primarily involved in incidents that occur in primarily rural areas such as farms, shoreline or mountainous terrain, or where risks include sporting stadiums, transport infrastructure, and high rise structures.

Another limitation related to the use of simulated tasks is the issue of ecological validity. There are a number of limitations to using a simulated task as mentioned earlier, with previous researchers identifying realism as the predominant negative aspect. For example, Lieberman et al. (2006; 2008) when considering the differences in laboratory versus field based stressor testing in the military, state that in most real world situations humans are exposed to a complex combination of stressors, including fear of death and injury, confusion, and uncertainty. The impact of this multi-stressor environment must be considered during planning and training for military operations and disaster relief since a decline in cognitive performance may occur (Lieberman et al., 2006), yet these skills are unlikely to be developed in response to laboratory simulations.

Whilst the incident command suite does provide a stressor based environment, all participants will be aware that there are no actual threats to the well-being of themselves or their colleagues, and that the simulation cannot be as demanding as an actual fire scene, suggesting that any initial effects within this study may be magnified at real life incidents, and therefore any abilities to recognise and deal with these demands in a reduced state through training may act as a base to implement potential coping strategies safely.

Participants reported very minimal physical demand from the task, with an overall average of only 20% of their physical tolerance required regardless of task, yet this is unlikely to be the case at a real incident. Rooms representing sides of the structure were set up next door to each other, facilitating ICS staff to observe all actions easily, yet this meant that incident commanders could easily manoeuvre between the three or four sector incorporated into this task, instead of hundreds of metres that would be involved at a real incident.

The participants in the exercise were also dressed in their ‘on-station’ uniform that did not involve wearing any of the ‘turnout’ PPE such as fire tunic, helmet or boots. The addition of firefighting PPE without SCBA has previously been found to increase oxygen consumption by between 10% (Baker et al., 2000) and 15-20% (Gravelling et al., 1999) compared to wearing short and t-shirts in UK firefighters undertaking a treadmill based walking task. Therefore, undertaking any command and control based activities at a real incident may be more physically demanding than reported in this study as a result of the additional PPE that will be worn. This increased physiological demand may then lead to further cardiovascular responses; with previous firefighter research by Webb et al. (2010) demonstrating how a mental challenge combined with a physiological challenge seems to exacerbate individual cardio respiratory responses.

There were also a number of environmental factors that were missing from the simulated task including incremental weather, such as wind or rain, pressure from bystanders to act unsafely to rescue lives, and any risk of structural collapse. The environmental demands of this operational scene will provide a significant challenge to the individual's physical, cognitive and affective resources and forcing them to initiate cognitive, affective and behavioural response strategies to perform the tasks required (Weston, 2012) that may not be experienced through simulation.

Furthermore, fire appliances, with a typical operating noise level of 63-85 decibels (Kales et al., 2009) would have also been a factor in attenuating optimal communication. Similarly, if the incident occurred during the night, there would have been an increased need for decision making to occur with limited vision and missing visual cues due to darkness, in addition to potential sleep deprivation, although such factors would also limit the ability for both researchers and firefighters to obtain measurements during suppression activities due to safety factors (Webb et al., 2010).

State anxiety was measured, although it is not known exactly what participants were specifically anxious about, since this was their first exposure to the incident command suite. As such, whilst the environment can be considered novel, future familiarisation with this location may be recommended to ensure more thorough knowledge and focus upon the context of the task, and not just the process of the simulation. For example, the presence of the cameras and microphones in each of the rooms were not covert devices and participants were aware they were being filmed in the control room leading to observation stress. This 'observation' stress would not be present at an operational incident, and as reported in chapter 4, this type of acute stressor is most prominent in less experienced firefighters.

Finally, regarding the questionnaire used to collect data, a number of limitations were identified. This study established that incident command is characterised by specific demands, yet the NASA-TLX remains ambiguous with definitions of these terms. For example, 'mental demand' included the participant stating how much 'perceptual activity' such as deciding, calculating, remembering or looking' they perceived, yet it is unknown how much of each contributed to the demand, or if the presence of one but not another affected participants scoring.

In addition, due to the time demands of the exercise, a primary objective was to create an inventory that could be completed quickly and as honestly as possible with limited resources such as a place to sit or write. As a result, the measure of state anxiety featured only six questions, unlike the 20 questions of the state-trait anxiety inventory (STAI) (Spielberger, 1983) more commonly employed in studies of state anxiety. Similarly, both stress and happiness were only a single-item, self-reported visual analogue scale and if further assumptions are to be made regarding stress reactivity, more thorough and validated measures may be more appropriate.

6.4.2.2 Performance

Unlike in previous studies that assessed occurrence of stress in a life-like workplace environment (Regehr et al., 2008), no measures of actual performance were taken in the current study. As a result, the effects of any stress or task demand upon performance are not known. It is further unknown how many of the skills learned during the simulation are transferrable from the training environment to on-the-job performance, and it would be unwise to assume that a single session would produce lasting changes in job performance at a real incident.

The limitation to measuring performance within this task is that it takes the emphasis away from training, and the idea that new ideas can be tried and mistakes made that may not be possible in a real-life fire situation. It is likely that if personnel thought they were being assessed on performance, they would be less willing to describe stress levels or demand characteristics, which was another primary aim of this study. As with previous studies in this thesis, it is often the anticipation and effect of being assessed that is more stressful than the actual task being undertaken. To ensure ecological validity, and since emergency call-outs are rarely assessed for performance by personnel outside of the watch in attendance, this may lead to invalid results if stress under observation is considered to be a contributing factor.

Therefore, if the study was to be repeated a possible solution would be to utilise covert expert-rated behaviour, or for the incident commander to pass opinion during the incident debrief on how he felt his personnel in each sector performed. This may include what they would do differently next time rather than as a score or pass/fail for the task. Given its benefit as a method of developing confidence in command decisions and dealing with consequences, identifying the mistakes made by an individual may not provide benefit to either the person involved or the organisation if mistakes made during this time are penalised.

6.4.3 Further research

6.4.3.1 Additional stressors

The results of this study should be kept in the context of the situation they occur and although the task was representative of a large scale incident, it was by no means exhaustive of the additional stressors that may be encountered at a large scale incident, with many work environments prone to high levels of performance-altering stressors (McClernon, 2009). Therefore the introduction of additional stressors into this environment is recommended to further increase ecological validity, including additional personnel arriving on scene, role rotation and the introduction of supporting agencies. Again though, this must be balanced out with the training and learning aspects of incident command training, with Friedman and Keinan (1992) describing how the introduction of stress training can often result in two counterproductive results that include high levels of anxiety that inhibit both training and post-training performance, and stress that interferes with the acquisition of skills and knowledge which the training is designed to promote.

It is assumed that incident commander stress occurred as a result of being in charge and accountable for decisions, therefore it would be logical to assess the incident once it had been classified to silver command level and therefore including the introduction of a more senior officer, and observe any changes or effects in anxiety or stress levels. Under silver-level command, the incident commander should be prepared to brief a more senior fire officer at any time so that the silver command- level officer can decide whether or not to assume command. Having assumed silver command the senior fire officer may elect to retain the previous commander in the command structure to give assistance (Incident Management Handbook, 2008). It would be interesting to observe if there is an increase in observation stress or longer time spent making decisions if the initial incident commander anticipated this may happen during the exercise. It may even be predicted that the initial incident commander suffers greater levels of stress and frustration due to encountering others who rank higher on the organisational chart but who may not possess the appropriate knowledge or skill for high-stress situation control (Langerman, 2007), and as such the level of control, and role allocation established by the individual may have to be given up solely because of their higher rank.

The introduction of a higher ranking officer to the exercise would provide a valid addition to further studies, and to do so alongside further measures such as perceived control, satisfaction, and stress measures of participants would be recommended. This is particularly relevant given the links between personnel who consider themselves to have a greater control over their external environment and feelings of confidence and alertness in trying to control this environments (Rotter, 1966), as discussed earlier in chapter 4.

In keeping with the central theme of this thesis, coping with these demands should also be considered, certainly now that more is known about what the broad task specific demands are likely to be, and ‘appraisal’ would be expected to form a key element of this coping. The 2008 incident management handbook states that in general, operational incidents will generate an increasingly intense command environment as the complexity and scale increase. The incident commander must also realise that intensity is also relative to the position and circumstances perceived by themselves. Therefore, one of the factors that is critical to the successful outcome of an incident is the ability of the incident commander to understand context and the complete environment within which they will be exercising command. In particular, a greater understanding of how the individual perceives this environment is closely related to appraisal of a situation. In a description of the simulation effectiveness of Navy simulation tasks, McClernon, (2009) describes how although physical fidelity is directly observable, and can be evaluated and analysed, psychological fidelity cannot. A training system can look and feel exactly like the system it is meant to train, but if the user does not perceive it to be the same, then there will be a loss in simulation effectiveness.

6.4.3.2 Inter-agency liaison

Personnel from each exercise were from the same duty watches, and therefore it can be assumed that they were already familiar with each other, and as such a high level of interpersonal trust should exist within the group allowing the incident commander to have faith in personnel assigned to individual roles. It would be interesting to note the differences in questionnaire scores if personnel did not know each other and were unfamiliar with each other’s capabilities.

Large incidents requiring incident command systems to be put in place are possible in areas where two or more fire service areas border each other, and crews from two separate fire services need to work together to meet the demands of the incident. This would also be likely if a specialist fire service team, another emergency service, or even military response was required. An example of this could include a structural collapse where a number of specialist urban search and rescue (USAR) teams may be deployed simultaneously from a number of UK fire rescue service to undertake a coordinated response to an incident, alongside Police officers, and ambulance service 'hazardous area response teams' (HART). On a larger scale, recent worldwide disasters such as the 2010 Japanese Tsunami or 2009 Haiti Earthquake have required a coordinated worldwide response from a number of different specialist rescue teams, including those from UK fire and rescue services.

The next step is to include other agencies; both for the expansion of methodological data collection, but also to establish practical experience of inter-agency working to improve on scene performance and cohesion between groups that may not often get the opportunity to train together. The benefit of this cohesion includes a collective focus, consensual sharing of meaning (Bass, 1985) and acts as a catalyst in eliciting higher levels of performance and commitment, especially given the need for firefighters and other emergency service workers to work closely as coordinated teams in the face of high environmental and personal dangers (Pillai & Williams, 2003).

6.4.4 Recommendations

The overall aim of firefighter's training is to improve performance at operational incidents to ensure the saving of life and safety of operational personnel, and therefore the introduction of any methods found through research should morally be introduced. Whilst performance measurement is not therefore recommended within this environment (i.e. identifying what the individuals did incorrectly against a set criteria), the use of error exposure may act as an alternative to the facilitators.

One of the key benefits of the immersive simulation method such as 'Minerva' is that it allows for instant post task feedback from exercise facilitators (Wilkerson et al., 2008). Therefore any errors identified during the task should be raised as feedback and not as a performance score to those involved and provide an important part of incident command debriefing. It is recommended that unlike in traditional theories of learning, where any errors are encouraged to be kept at a minimum level and are conceptualised as a negative event associated with stress and poor performance (Naikar & Saunders, 2003), instead an error exposure approach should be utilised where any consequences are considered and managed. This includes the learner committing errors, either themselves or by watching someone else commit errors and receive feedback about their mistakes (Joung et al., 2006) instead of the errorless approach where learners are prevented from experiencing error. Although skills relating to the effortless and quick acquisition of skills required for routine performance and reinforcement of standard operating procedures are essential for firefighters, the addition of error exposure training has been attributed to dealing with new and complex situations, retention after long delays, transfer to novel situations, and produces more problem solving actions due to the building of accurate mental models (Joung et al., 2006).

However, if the potential introduction of error exposure training instead of subjective performance scoring within this task is introduced as a performance measure, great care must be taken to ensure that this is balanced out with potential negative effects. These have been previously stated to include negative thoughts, frustration (Kanfer & Ackerman, 1989), lowered levels of self-confidence, self-esteem or self-efficacy (Wood et al., 2000) from participants post task.

Further research examining the self-rated responses of fire service personnel, including stress, anxiety, control and perceived coping following the implementation of error-exposure approach to feedback instead of a performance evaluation, would provide invaluable information and insight into this field. The initial findings of Joung et al. (2006) indicate that trainee fire commanders exposed to this training are able to identify incident command errors earlier than a control group, and this skill can be considered a key element of successful command in the field.

6.5 Conclusion

The training of personnel in SCBA command and control is widely acknowledged as a difficult area to establish and maintain despite being essential for effective disaster response regardless of specific emergency service. The problems further arise when this training involves skills pertinent to and experience of high-acuity, low-frequency events that facilitate crew performance by increasing the likelihood that appropriate decisions are made in the stress and chaos of the moment and transferred from training to real-life environments (Wilkerson et al., 2008). Exposure to a simulated exercise was found to produce a series of changes in levels of state anxiety, stress and happiness in the four roles typically required at a bronze level response to such incidents. There were a number of factors considered demanding, namely the mental demands and temporal demands, with effects most profound in incident commanders. Implications for responses to real-life incidents are yet to be fully understood, and methodological issues identified are consistent with the observations of Rose et al. (1998) who state how there have been relatively few attempts by researchers to empirically investigate the virtual to real transfer process in terms of what sort of training shows transfer, in what conditions, to what extent, and how robust the transferred training proves to be.

Chapter 7
General conclusion and applied implications

"One of the issues that should be considered in organisations with a hierarchical command structure relates to a potential conflict between a training approach based upon critical and adaptive thinking, and traditional practices that are designed to ensure compliance with standard operating procedures"

Joung et al. (2006, p.299)

Chapter 7 – General conclusions and applied implications

7.1 Research rationale

In response to the large number of firefighter deaths and injuries each year in the US (more than 100 firefighters dead, over 80,000 injured) and UK (one on-duty death every three months for the last 30 years) the primary aim of this thesis was to improve firefighter well-being. This was hoped to be achieved through addressing the physiological impact, cognitive demands, and coping strategies of UK firefighters when wearing self-contained breathing apparatus (SCBA) in structural fires that include residential dwellings, commercial properties, and large scale industrial units. By understanding the specific impacts, and by exploring the successful coping strategies used by experienced firefighters to manage such effects, it was hoped that initial recommendations for educational strategies and training environments can be developed.

Previous firefighter research remains limited, and the requirement for further study into factors that may affect firefighter well-being or performance has been noted by a number of researchers. Moore-Merrell et al. (2008) state that academic interest in firefighters' occupational risks and hazards has increased in recent years, but many of these papers analyse contributing factors outside the context of specific fireground incidents and training exercises, and like the majority of academic papers, have examined a highly localised sample population (Austin, 2001). Similarly, Putnam (1996) has described how recent approaches to fire and rescue research have placed an emphasis upon understanding how the fire, and not the firefighter, behaves under specific environments.

To achieve this aim, a number of further objectives were incorporated. These included the identification of specific on-duty stressors considered most demanding by UK firefighters, and the coping strategies utilised to deal with these stressors (chapter 3). Following the finding of SCBA activities as the most physically and psychologically demanding task, chapter 4 looked at the development of coping strategies in early career firefighters in response to key SCBA milestones whilst also examining links between perceived control over the task and coping effectiveness. Differences between novice and experienced firefighters undertaking a live fire task, and the situation-specific psychological and physiological responses to the three most common SCBA tasks were investigated in chapter 5. Finally the stress reactivity during the command and control of SCBA tasks were considered within four key roles during immersive training environments (chapter 6).

This chapter will summarise the key findings from each of the research objectives identified in the introduction. Further recommendations for future research and applied implications for the fire and rescue services are discussed.

7.2 Objective 1: What are the specific on-duty stressors considered most demanding by UK firefighters?

7.3 Objective 2: What are the techniques used by firefighters to cope during exposure to acute stressors present on the fire scene?

Chapter 3 provided the starting point for the structure and nature of the thesis, and attempted to answer the first two objectives through the use of focus groups conducted with experienced personnel. Follow up interviews were then undertaken with firefighters at one of the three career stages identified as early, mid, or late career. Given the complexity of the coping process and due to the current lack of understanding or validated data collection methods within this population, an open-ended exploratory method was employed with a number of focus groups. Examination of the data revealed the emergence of 121 unique responses grouped into 17 categories, which were subsequently further grouped into five higher order categories. These higher order categories included: physical demands of firefighting, risk of injury, cognitive demands of firefighting driving, and dealing with fatalities. The physical demands stressor accounted for over two thirds of all responses by the firefighters and crew managers taking part. The general finding amongst participants was that fires in residential, marine and commercial premises are the most demanding task faced by firefighters due to their frequency during a typical shift and provided a key finding in terms of follow up research undertaken for the thesis.

In keeping with the theoretical model proposed by Lazarus and Folkman (1984), two broad coping themes consisting of problem and emotion focused coping techniques were utilised to group participants' responses to fires. Of the coping strategies reported by firefighters, problem focused approaches (consisting of experience; cognitive awareness, and nutrition and hydration) comprised half of the total coping strategies quoted by participants, with a third of responses being categorised as emotion focused methods, and 17% were considered to be both problem and emotion focused techniques. Responses from those involved in the study indicate that problem focused methods are often utilised en-route to the incident, and at the early stages of breathing apparatus tasks. Emotion focused responses are more commonly used during periods of fatigue and exhaustion and post incident, and problem and emotion focused techniques were found post-incident although there was often an overlap between methods and they perhaps should not be treated as three distinct stages.

Individual interviews, driven by earlier sport-based research of athlete lifespan coping (i.e. Skinner & Zimmer-Gembeck, 2007) considered the re-organisation of coping skills at different career stages and found different stressors exist at different stages. Whilst early career is associated with control of arousal, participants in mid-career described the fear of making mistakes and judgement during training exercises, and finally, participants in the latter of the stages of their career had to deal with degradations (and the frustration of these degradations) in their physical attributes.

In terms of applied implications, it was found that the use of the Lazarus and Folkman (1984) transactional model of coping could be applied, with the findings of this study consistent with extensive elite athlete research that have used this model when examining coping during fatigue, errors and risk of injury. The most frequent coping strategies identified by participants in this study were reported as being experienced and developed in fire service specific training environments. This was often achieved by pushing themselves to their physical and psychological limits during tasks that are either hotter or more complex than anything they are likely to encounter at real-life incidents, and developing coping strategies during this time. Recommendations are consistent with military research such as Kavanagh (2005) who stipulates that both skill-building and stress-combating are important aspects of the training environment. This notion of ‘adaptive capability’ has important implications for fire and rescue, where it is impossible to practice every single scenario that may be faced, and can be expected that the ability to apply knowledge and skills through training and experience can be applied to more complex and novel situations.

7.4 Objective 3: How do the coping strategies used at SCBA specific incidents develop?

Chapter 4 utilised a 12-month longitudinal methodology similar to that of Nicholls et al.'s (2006) research of athletes to investigate the demands and coping abilities of firefighters in early career using self-reported measures. The tasks undertaken by this group included the first SCBA wear undertaken by the recruit firefighters, their first ever 'live' fire task, their first experiences of SCBA at real life incidents, and assessment in live fire conditions on return to training school.

In general, the participants of this study reported that of the five unique categories relating to the stressors and demands of wearing SCBA, those considered to contain either physical and cognitive stressors accounted for almost two thirds of all stressor responses over the twelve month period. Physical demands of tasks, in particular having to work in extreme heat, were found to be most profound during tasks experienced at training school, whilst cognitive demands were stated as being most frequent during operational / real life incidents. Observation stress was found whilst at training school, whist attending novel environments were reported whilst on the fire station.

To cope with these demands, firefighters reported using the use of all eight coping strategies identified by the Folkman and Lazarus (1985) Ways of Coping Questionnaire (WOC) at each stage of data collection. Of the eight methods, both 'problem focused coping' and the use of 'self-blame' methods were used to the greatest extent by participants over the twelve month period, although there was no single dominant method present. Due to the different coping methods reported to be effective at different times in different contexts, both a range of problem and emotion focused approaches are recommended.

A number of limitations of this study are acknowledged within the chapter, including difficulties of retrospective recall of events (Giacobbi & Weinberg, 2000), where participants potentially fail to accurately recall the coping strategies deployed, with others forgetting the coping strategies used, or alternatively over-reporting the coping strategies used. The study was limited due to the attrition rate of participants, particularly during the mid-stages of data collection when questionnaire returns fell to under 30% and therefore limiting the use of formal statistical analysis. Despite the small sample and methodological limitations, results were in line with previous athlete research and provide further support for the Lazarus and Folkman (1984) transactional model of coping.

There were also issues related to the appropriateness of the coping inventory used, and in response to similar issues Dowdall-Thomae et al. (2008) have recently developed the 'Revised Ways of Coping Checklist for Firefighters' using the Revised Ways of Coping Checklist (Vitaliano et al., 1985), that included additional wording relating to the abilities of firefighters to transition from one firefighting incident to another. Unfortunately, at the time of this research taking place, such an occupation specific tool was unavailable, although the high reliability and similarity of the five coping categories measured by the WOC in this study suggests that this inventory has the potential to be utilised within the population of UK career firefighters for future coping research.

As in chapter 3, it was identified that trainee firefighters utilise training school to establish and identify optimal coping strategies, yet it is unknown how transferrable these skills are when on station. Overall, very few stressors related to exposure to novel environments at training school despite their high perceived frequency at operational incidents, and future training environments should therefore consider a focus upon situations novel to participants, but where the assessment and observation is more covert by training officers.

7.5 Objective 4: What are the physiological and psychological responses of novice and experienced firefighters undertaking firefighting and SCBA tasks?

The next stage of research explored utilised a two-phase approach. The first considered the differences between novice and experience firefighters undertaking a live fire exercise, before a further study assessed the specific demands of three common SCBA exercise using both physiological and psychological measurements. For this study, the evidence provided in chapters 3 and 4 has suggested that the training environment is as difficult, if not often more difficult than the majority of operational incidents, and as such all testing was undertaken in a purpose built breathing apparatus training structure.

Undertaking a single firefighting exercise in temperatures of around 180^{o} Celsius, was found to lead to a significant increase in the heart rates of both novice and experienced firefighters most profound in the novice participants, with the effort required to complete the task comparable to previous research such as Elgin and Tipton (2003). The live fire task was found to require around 74% and 54% of the participants' age-predicted maximum heart rates which were below previous research that has reported levels closer to 90% of heart rate maximum (i.e.

Holmer & Gavhed, 2007) after comparable tasks. Self-reported levels of alertness were found to significantly decrease in the novice participants alone, suggesting that experienced or skilled performers may be more resistant to the effects of heat through automisation of their skills (Hancock, 1986).

In phase two, there was little difference between the demands of guideline, search and rescue, and live firefighting exercises undertaken by experienced firefighters, although all three tasks produced high demands on the NASA-TLX (such as high physical, temporal, and frustration levels). It remains unknown if levels of alertness and calmness remain stable throughout the tasks or if firefighters intentionally monitor these areas to ensure their safety and the wellbeing of those around them.

Findings suggest that training officers should consider the use of physiological measures and self-reported psychological measures to validate the effectiveness of training activities and ensure that firefighters be given the opportunity to train in conditions of high physical and mental demands. Increased education for firefighters, training officers, entry control officers, and incident commanders is recommended to understand the likely demands of SCBA tasks, and identify potential decreases in the alertness levels of firefighters. Due to the differences between calculated and actual air usage during the tasks in phase two, incident commanders should not consider air cylinders by their duration only, as this is misleading and potentially dangerous. Instead they should designate cylinders by their nominal volume, and ensure a good working knowledge of maximum rates of air consumption for specific tasks to ensure that firefighters can safely exit irrespirable atmospheres before critical lack of air supply, consistent with research by Williams-Bell et al. (2010).

There were also a number of methodological issues that arose as a result of testing. These included the difficulties in being able to manipulate variables or incorporate control groups as the training was pre-programmed, small sample sizes due to the strict health and safety control put in place for training exercises, and being unable to accurately identify how close the demands of the training tasks are to the demands of a real-life incidents.

It would be unwise to compare the findings of this study to other research since the different responses reported by different firefighter research studies are likely attributable to differences in the intensity of the firefighting task (Smith et al., 2001), with the findings of SCBA studies also being highly task dependent

(Rayson et al., 2005). In the UK, as there is no standardised protocol or exercise briefs for SCBA training exercises, such tasks will vary according to the locations (or participating fire and rescue services) that took part in the study.

7.6 Objective 5: To investigate the patterns of stress reactivity during the command and control of large scale incidents that require the use of SCBA

Each of the previous chapters examined the issue of SCBA tasks from a physical perspective, with participants describing (or having their responses measured) in terms of the cognitive effects present during fatigue. However, during larger SCBA incidents, fireground incident commanders are not the only personnel involved in the command and control process, and frontline firefighters also have to make decisions in accordance with their individual competence and situational awareness, including in command and control duties. Sharkey, Miller and Palmer (2011) suggest that if firefighters are to continue working in incident management they will need to improve their ability to deal with the stresses of the job, including being able to maintain operational effectiveness, and avoid some of the negative effects that may lead to adverse decision making in field command roles. One of the ways this is achieved is through the use of immersive, interactive scenarios such as the ‘Minerva’ system (Crego, 2007), where personnel are able to try out their skills, solve command problems and overcome the challenges of these events.

This study was the first to examine the role specific demands of large scale firefighting activities, and found that exposure to a simulated SCBA incident command exercise produced a series of changes in levels of state anxiety, stress and happiness in the four roles (incident commander, sector commander, entry control officer, and command support officer) typically required at a bronze level response to such incidents. Results study found that a large amount of effort was required to meet the demands of the task, characterised by significant levels of mental and temporal demand comparable with Webb et al. (2011). Of the four roles, the incident commanders reported the highest levels of stress both pre and post task, with post task levels found to increase significantly greater than the entry control officers, and command support was the only role to demonstrate a decrease in levels of stress. Incident commanders also started and finished the task with the highest levels of state anxiety, although both levels could be considered to be relatively low levels. A rise in state anxiety was also found in the entry control officers, whilst command support officers demonstrated a decrease in anxiety post task.

Participants reported minimal physical demands from the task yet this is unlikely to be the case at a real incident. There were also a number of environmental factors that were missing from the task including incremental weather, such as wind or rain, noise, pressure from bystanders to act immediately, and the potential risk of structural collapse. Further research should continue to utilise the immersive simulated environment due to practicality and cost factors, but should also attempt to establish practical experience of inter-agency working to improve on scene performance and cohesion between groups that may not often get the opportunity to train together (Pillai & Williams, 2003). Research should also consider the implementation of correctly structured, error-correction based feedback to enable facilitation of control, self-confidence and motivation of individuals to react appropriately when such incidents are experienced in real life (Joung et al., 2006).

7.7 General recommendations

There were two predominant themes that emerged from the chapters that can be considered to be of benefit for firefighter performance and well-being, primarily the importance of the training environment, and secondly the introduction of education training strategies.

7.7.1 The training environment

There is evidence from the current studies that the training environment closely represents the physical demands of real incidents However, fire researchers such as Williams-Bell (2010) have stated that firefighters do just see this as training and key cognitive demands cannot be met in this way. As a result, the extent that skills learned during the training exercises are transferrable to on-the-job performance is not known. Similar methodological issues have also been identified in military based research; in particular the difficulties in replicating stressors present in the real world including fear of death and injury, confusion, and uncertainty in laboratory based or simulated training environments (Lieberman et al., 2006). Consequently, current findings suggest that training instructors should work hard to ensure that training environments regularly incorporate factors such as novel outcomes, fatigue, task uncertainty, providing limited information to personnel, and reinforcing a time critical aspect, as these will be experienced at real incidents and are a source of stress.

The findings of this thesis often contradicted each other in suggesting optimal training environments, in particular the issue of novel conditions. The findings of chapters 3 and 5 suggest that although there is the high risk of physiological strain to personnel, firefighters should be given the opportunity to use the extremity of the training environment in order to gain experience of working under this strain, and to gain the confidence and control from overcoming these demands in a controlled environment. Firefighters in training environments should push themselves to their physical and cognitive limits prior to the task being completed, without fear of reprimand for doing so in order to establish their physiological and psychological boundaries and develop coping methods for consistent performance at real incidents. However, the contrasting findings of chapters 4 and 6 suggest that familiarity may be more beneficial as firefighters can gain experience under familiar conditions, learn to listen to their bodies and draw information cues from them which may not develop during periods of high intensity.

There is the debate if performance should be assessed during training. The observation stress found in training environments created a stressor that must be managed but is unlikely to be required at a real incident. There is the suggestion that training environments should provide the platform for techniques to be developed (including coping strategies) and mistakes made without the risk of serious injury. However, without an objective measure of performance, it is not clear whether the firefighter gains all the benefits from learning from any mistakes made, and whether the firefighter can be judged as competent to perform in real-life situations. Information obtained from the training environment in phase two of chapter 5 included the time to complete task (as measured by their entry control board) yet this does not indicate how well the firefighter performed. One option which was introduced in greater detail in chapter 6 was the use of error exposure instead of error identification (i.e. identifying what the individuals did incorrectly against a set criteria). In this model, any errors identified during the task should be raised as feedback and not as a performance score to those involved and provide an important part of debriefing. It is recommended that unlike traditional theories of learning, where any errors are encouraged to be kept at a minimum level and is associated with stress and poor performance (Naikar & Saunders, 2003), an error exposure approach should be utilised instead, whereby any consequences are considered and managed. Further research examining the self-rated responses of fire service personnel, including stress, anxiety, control, and perceived coping following the implementation of error-exposure approach to feedback instead of a performance evaluation would provide invaluable information and insight into this field. The findings of Joung et al. (2006) indicate that trainee fire commanders exposed to error exposure training are able to identify incident command errors earlier than a control group, and this skill can be considered a key component of successful command in the field.

7.7.2 An educational approach

The second theme to emerge was the use of educational strategies to inform firefighter response. This is in keeping with the recommendations of researchers such as Holland (2008) who advocate the use of educational seminars in the implementation of optimal coping methods and the avoidance of detrimental coping methods to ensure the psychological endurance of emergency workers. Regehr et al. (2003) have recommended that education about incident stress and self-care must begin in initial training to ensure individuals develop strategies for coping with stress, but also that these educational programmes should continue throughout an individual's career. The ability to identify acute stressors has the potential to prevent emotional exhaustion in emergency workers, that includes occupation 'wear and tear' factors such as work overload, depression, anxiety, and hypertension (Murphy et al., 1999), and provides an method effective of improving firefighter well-being.

The research undertaken in this thesis does not allow for the definitive effects of SCBA to be stated, but the results can educate firefighters as to the *potential* of experiencing physical and psychological demands and to consider 'proactive' coping ahead of 'reactive' methods as early as possible. The outcome of training and intervention strategies to this population is hoped to provide 'psychological protection' (Shubert et al., 2008) to mistakes and stressors that will be encountered in early career, as well as providing a framework to assist with future coping strategies.

Coping is described as how the individual has reacted to and managed stressors that have already occurred (Tamminen & Holt, 2010a), yet coping is more than just what has happened and can be about future behaviours and strategies. In order to incorporate future-orientated models, it is important to consider the ways in which individuals respond to stressors, the ways in which they may learn from these experiences, and how the individual plans to deal with stressors that may occur in the future. This idea of future orientated coping is based upon the notion that many of the stressors people encounter can be avoided, but if the stressors are unavoidable (such as in the fire service), the severity of stressors can at least be decreased by engaging in future oriented coping strategies. Consistent with elite athlete education, it is recommended that rather than there being a set of effective coping strategies which can be prescribed to deploy in given situations, practitioners should instead consider teaching how to plan and evaluating their coping by encouraging individuals to reflect upon their coping. The outcome of this approach is that firefighters should then begin to understand when and under what circumstances certain strategies are likely to be effective or ineffective (Tamminen & Holt, 2010).

Further research is recommended to examine the ways in which management of stressors and effective coping methods (in particular problem focused methods) can be embedded into the fire and rescue service by watch officers at their fire station. Finally, the identification of the relationship between coping strategies and performance, as well as the relationship between outcome coping efficacy, mental toughness and optimal performance under stress is required to facilitate firefighter performance and well-being.

7.8 Overall conclusion

In summary, firefighting activities are subject to a multitude of tasks, durations, and outcomes, and are associated with numerous physiological and psychological factors, although many other facets, such as areas of cognition, have yet to be investigated due to limited methods of collecting firefighter-specific data. The ways firefighters are able to successfully cope with the acute aspects of these demands remains open to interpretation, and whilst the findings of this thesis attempt to address and explain these issues, extensive follow up research is recommended to address the methodological considerations that further add to the complexity of undertaking firefighter research.

APPENDICES

APPENDIX A

Example of the Northumbria University School of Life Sciences Consent Form and Participant Information Sheet

PARTICIPANT INFORMATION.

TITLE OF PROJECT: _ Modern demands of firefighting: Cognitive and psychophysiological stress responses to maximal effort and live fire exposure in UK fire fighters.

Participant ID Number:

Principal Investigator: ____Paul Young____

Investigator contact details: Email: paul.m.young@northumbria.ac.uk

This project is funded by: The Institution of Fire Engineers (IFE) Training and Research Fund

Number of participant points / payment: N/A

INFORMATION TO POTENTIAL PARTICIPANTS

1. What is the purpose of the project?

Fire fighting is an aerobically demanding occupation where the nature of the job can require turning out to multiple hot-fire incidents within a short period of time. Whilst the physical aspect of being redeployed is understood, it remains unknown how much our thought processes (cognition) are affected when we are in fire, or how long it takes for areas such as visual and auditory identification to return to normal levels. This research aims to investigate the effects of maximal effort and hot fire tasks upon physiological and cognitive responses in trainee fire fighters and how long it takes for these responses to return to normal after effort. Observation of cognitive responses will be undertaken using a short computer based task, whilst physiological measures will be done using a heart rate monitor and saliva samples to measure the activity of the nervous and hormonal systems

2. Why have I been selected to take part?

Trainee firefighters represent an ideal sample as the live fire training you undertake is under controlled and risk assessed conditions, and for many of you will represent the first time you have encountered such a situation.

It is important that we assess as many people as possible and you have indicated that you are interested in taking part in this study, and that you are current a trainee firefighter undergoing training at the breathing apparatus training centre.

3. What will I have to do?

You will be asked to attend a testing session held at a number of key times during your time at the BATC; upon entry to the centre, prior to starting the BA exercise, immediately upon exiting the structure and during a period 10-30 minutes after the exercise.

On attending this session you will be met by the investigator and allowed to ask any questions concerning what you will later be asked to do. After signing a consent form, the researcher will ask you to complete a short questionnaire requesting some biographical information (e.g. gender, age etc.). While there are no questions on this form that are felt to be invasive or embarrassing, should you wish to omit some answers (for whatever reason) then that is fine. The investigator will provide you with a pen if you have not brought one with you. You will also have a heart rate monitor attached by the researcher, and this will be kept on for the duration of the day.

The investigator will then lead you to a laptop containing a 10 minute multi-tasking exercise and ask you to begin the test. Please note that you cannot fail this task, although it will provide a score. You will also be given two short questionnaires asking you about your current mood and how demanding you thought the task was.

You will then undertake this same procedure before and after your BA exercise. After you have completed this procedure for the final time the researcher will give you a debrief sheet explaining the nature of the research, how you can find out about the results, and how you can withdraw your data if you wish.

It is estimated that the total time to complete each part of the study will be a maximum time of 15 minutes.

Two or three participant will complete each phase at a time, though it is important to stress that participation is as an individual.

4. What are the exclusion criteria (i.e. are there any reasons why I should not take part)?

There is no reason you cannot take part in this research, as the live fire tasks form a part of your initial firefighter training course with Tyne and Wear Fire and Rescue Service.

The only possible exclusion criteria is if you are deemed unfit to carry out a BA exercise by the instructors at the BA training school, or are allocated the role of BA entry control officer during the task.

5. Will my participation involve any physical discomfort?

No physical testing will be carried out by the research team. Our purpose is to examine potential changes that may occur after the live fire BA exercises that form a compulsory and important part of your initial firefighter training course.

6. Will my participation involve any psychological discomfort or embarrassment?

The cognitive tests used are not designed to cause any discomfort or catch you out, and there are no high or low scores assigned that may cause embarrassment. The mood and perceived workload inventories that you will be asked to complete do not contain any personal or intimate questions.

7. Will I have to provide any bodily samples (i.e. blood, saliva)?

Saliva samples will be collected by asking you to chew on a cotton swab for a short period of time. This is a standard collection method of saliva and has been widely used by researchers for a number of years as it is reliable and non-invasive to yourself These samples will then be analysed for levels of a hormone called cortisol which is related to mood and feeling of stress. All the procedures will be conducted by appropriately trained staff and have been risk-assessed.

8. How will confidentiality be assured?

The research team has put into place a number of procedures to protect the confidentiality of participants. These include:

You will be allocated a participant code (such as a number) unique to you that will always be used to identify any data that you provide. Your name or other personal details will not be associated with your data, and all personnel outside the University research team will not have access to which participant code is allocated to each participant. The consent form that you sign will be the only time your name will be required and will be kept separate from your data.

All paper records will be stored in a locked filing cabinet, accessible only to the research team, and all electronic information will be stored on a password-protected computer. In general all of the information you provide will be treated in accordance with the Data Protection Act.

9. Who will have access to the information that I provide?

Any information and data gathered during this research study will only be available to the research team identified in the information sheet. Should the research be presented or published in any form, then that information will be generalised to a group and your own personal scores and data will not be identifiable or accessible to any person or organisation.

10. How will my information be stored / used in the future?

All information and data gathered during this research will be stored in a locked cabinet only accessible to the researcher and in line with the Data Protection Act. The data may be used by members of the research team only for purposes appropriate to the research question, but at no point will your personal information or data be accessible or revealed to Tyne and Wear Fire and Rescue Service.
Insurance companies and employers will not be given any individual's information, samples, or test results, and nor will we allow access to the police, security services, social services, relatives or lawyers, unless forced to do so by the courts.

11. Has this investigation received appropriate ethical clearance?

Yes, the study and its protocol have received full ethical approval from the School of Psychology & Sport Sciences Ethics Committee. If you require confirmation of this please contact the Chair of this Committee, stating the title of the research project and the name of the principal investigator:

Chair of School of Psychology & Sport Science Ethics Committee,
Northumberland Building,
Northumbria University,
Newcastle upon Tyne,
NE1 8ST

12. Will I receive any financial rewards / travel expenses for taking part?

No expenses are paid for taking part

13. How can I withdraw from the project?

As this research is being conducted independently from your trainee course you can withdraw from this research at any time without any reprimand or discrimination from your training course instructors.

The research you will take part in will be most valuable if few people withdraw from it, so please discuss any concerns you might have with any of the research team. During the study itself, if you do decide that you do not wish to take any further part then please inform one of the research team as soon as possible, and they will facilitate your withdrawal immediately. Any personal information or data that you have provided (be it in paper or electronic form) will be destroyed and deleted as soon as possible.

After you have completed the research you can still withdraw your personal information / data by contacting the lead researcher (e-mail provided below), give them your participant number or if you have lost this give, them your name. Any personal information or data that you have provided (be it in paper or electronic form) will be destroyed/deleted as soon as possible.

14. If I require further information who should I contact and how?

Should you wish to ask further questions, to register a complaint, or to withdraw your date from this study the lead researcher for this project is Paul Young who can be contacted via e-mail at:
paul.m.young@northumbria.ac.uk

INFORMED CONSENT FORM

Project Title: Modern demands of firefighting: Cognitive and psychophysiological stress responses to maximal effort and live fire exposure in UK fire fighters.

Principal Investigator: _Paul Young___________________________

Participant Number: ______

	please tick where applicable
I have read and understood the Participant Information Sheet.	☐
I have had an opportunity to ask questions and discuss this study and I have received satisfactory answers.	☐
I understand I am free to withdraw from the study at any time, without having to give a reason for withdrawing, and without prejudice.	☐
I agree to take part in this study.	☐
I would like to receive feedback on the overall results of the study at the email address given below. I understand that I will not receive individual feedback on my own performance. Email address………………………………………………………………	☐

Signature of participant... Date.....………………..

(NAME IN BLOCK LETTERS)..………………………

Signature of Parent / Guardian in the case of a minor

....

Signature of researcher... Date.....………………..

(NAME IN BLOCK LETTERS)..………………………

PARTICIPANT DEBRIEF

TITLE OF PROJECT: Modern demands of firefighting: Cognitive and psychophysiological stress responses to maximal effort and live fire exposure in UK fire fighters.

Principal Investigator: ____Paul Young____________________________________

Investigator contact details: Email: __paul.m.young@northumbria.ac.uk_______

Participant Identification Number: __________

1. What was the purpose of the project?

The purpose of the project was to examine how much our thought processes (cognition) are affected when we are in fire, or how long it takes to return to normal levels. We also looked at how individuals react to extremely stressful situations. This research aimed to investigate the effects of maximal effort and hot fire tasks upon physiological and cognitive responses in trainee fire fighters.

2. How will I find out about the results?

Once the study has been completed and the data analysed approximately 12 weeks after taking part, I will email (or post if preferred) a general summary of the results.

3. Will I receive any individual feedback

No individual feedback will be provided. In keeping with standard research practices and to protect your anonymity you will only receive a general summary of the data from the full study.

4. What will happen to the information I have provided?

The data you provide their data will be stored safely, will always remain confidential and will be destroyed after two years.

All paper records will be stored in a locked filing cabinet, accessible only to the research team, and all electronic information will be stored on a password-protected computer. In general all of the information you provide will be treated in accordance with the Data Protection Act.

With the exception of the researcher, at no time will any individual data you have provided be made accessible or seen by any personnel employed by Tyne and Wear Fire and Rescue Service.

5. How will the results be disseminated?

The data collected will be written as a report to the Institution of Fire Engineers in

June. It is also hoped that the data may be published at a scientific journal and presented at a conference at a later date. However this data will be generalised, and your individual data and personal information will not be identifiable.

6. Have I been deceived in any way during the project?

No deception was necessary in order to undertake this research. However, if you feel that you have been deceived in any way you can raise your complaint with the lead researcher Paul Young via e-mail at paul.m.young@northumbria.ac.uk
Alternatively, you may wish to contact Dr Nick Neave, the chair of the Northumbria University Ethics Committee at nick.neave@northumbria.ac.uk

7. If I change my mind and wish to withdraw the information I have provided, how do I do this?

If you do decide that you do not wish to take any further part and withdraw your personal data then please inform one of the research team via e-mail as soon as possible with your name or participant identification number, and they will facilitate your withdrawal immediately. Any personal information or data that you have provided (be it in paper or electronic form) will be destroyed and deleted as soon as possible.

If you have any concerns or worries concerning the way in which this research has been conducted, or if you have requested, but did not receive feedback from the principal investigator concerning the general outcomes of the study within a few weeks after the study has concluded, then please contact Professor Kenny Coventry via email at kenny.coventry@northumbria.ac.uk, or via telephone on 0191 2437027.

APPENDIX B

Focus group question plan

<u>Question plan for firefighter focus group</u>

- Ground rules

....

- Describe the most common role-related tasks that deal with during the shift pattern?
- How often do you feel these demands are placed upon you?
- Describe the thoughts that commonly go through your mind before, during and after a fire. Does this differ if persons are reported inside?
- What/ if any differences do you notice in your mood state, such as alertness, self-confidence or elation before and after incidents?
- Have you ever reached a self-perceived maximal physical effort during an operational incident?
- Which conditions do you feel cause the greatest physical exertion and why:
    - tasks with high complexity
    - those in the middle of the night
    - incidents that immediately follow completion of another
    - general firefighting
    - search and rescue
    - special services (swift water, road traffic collision, animal rescue)
- Do you have any set routines for remaining hydrated before and after a fire?
- Do you notice any problems with any of your thinking, such as hearing, vision or memory when working at high intensities? If so how do you overcome these?
- How much do you think your previous operational experience plays with helping to overcome operational incidents requiring high physical exertion?
- How much do you feel personal protective equipment, breathing apparatus or chemical protection suits have on your fitness and performance during operational incidents?

....

- Thank you for taking part

APPENDIX C

Individual interview question plan

- Describe how long you have been an operational firefighter?
- Describe the most common role-related tasks that deal with during the shift pattern?
- How often do you feel these demands are placed upon you?
- What/ if any differences do you notice in your mood state, such as alertness, self-confidence or elation before and after incidents?
- If you were to be turned out now, what would be the single greatest source of stress en route to the incident, in the initial stages of the incident, during the incident and post incident. Are these the same as when you first joined the fire service?
- Im going to describe and define some of the common methods that have been previously identified in psychology research. Can you tell me if you use any of these, how you think you may use them, and if this has changed throughout your career:
    - Problem focused methods
    - Emotion focused methods
    - Both
    - Then expand upon answers to include specific situations
    - Why and how do you think these changed and envolved throughout your career?
- Do you have any set routines for dealing with the demands of SCBA incidents
- Do you notice any problems with any of your thinking, such as hearing, vision or memory when working at high intensities? If so how do you overcome these?
- How much do you think your previous operational experience plays with helping to overcome the demands of training environments or operational incidents?
- If you could offer one piece of advice to a firefighter in early / mid / late career stages on how to cope with the demands of BA, what would this be?

....

- Thank you for taking part

APPENDIX D

Longitudinal study data collection booklet

PRIVATE AND CONFIDENTIAL

Paul Young (Lead Researcher):

Breathing Apparatus demands and coping strategies in early career firefighters

Participant Questionnaire Booklet

Participant Number:...

Date of Completion:...

Northumbria University

School of Life Sciences

INSTRUCTIONS

Based on your physical and mental experiences of wearing breathing apparatus in January 2011, please complete the following questionnaires as openly and honestly as you can. Completion of the booklet should take no more than around 10 minutes.

There are no right or wrong answers and none of the answers you provide will effect your employment with the fire service or your ability to undertake your role. The aim is simply to examine the coping patterns and demands of specific breathing apparatus tasks undertaken during early career.

Suitable activities include both training (station and BTC) and real life incidents wearing breathing apparatus under any conditions (i.e. house fire persons reported, car fires, guideline laying etc.). **However, please do not state any names of other wearers/ specific addresses/ incident numbers/ locations.**

BA logbook numbers or any further evidence is not required.

Please note that if there is a question that you feel uncomfortable with please feel free to leave this blank.

ALL RESPONSES ARE CONFIDENTIAL AND ANONYMOUS

THIS IS AN INDEPENDENT PROJECT BEING UNDERTAKEN BY NORTHUMBRIA UNIVERSITY AND YOU HAVE THE RIGHT TO WITHDRAW FROM THIS PROJECT AT ANY TIME WITHOUT THE RISK OF ANY PENALISATION.

CONTACT:

In the event of any questions or concerns I can be contacted via:

e-mail – paul.m.young@northumbria.ac.uk

mobile –

Thank you for your participation

Contents

1. Task information
2. Borg Scale
3. Ways of Coping Questionnaire

TASK INFORMATION

1. **Describe the most stressful or demanding breathing apparatus task you have undertaken in the past week**

....
....
....
....
....
....
....
....
....
....
....
....
....

Please tick the context(s) this was in:

- ☐ **Live Fire**
- ☐ **Ambient (cool temperatures)**
- ☐ **Real life**
- ☐ **Training (station)**
- ☐ **Training (BTC)**
- ☐ **Search and Rescue**
- ☐ **Firefighting**
- ☐ **Comfort wear**
- ☐ **Guidelines**
- ☐ **Gas tight suit**

2. **What do you consider to be the three factors that made this task so demanding or stressful**

1...
....
....
....
2...
....
....
....
3...
....
....
....

3. **Please indicate along the line how much overall control you considered yourself to have over this task.**

No control ***Complete control***

0 10 20 30 40 50 60 70 80 90 100

4. **Please indicate along the line how effective you considered yourself to have dealt with the demands of the task, and how effective any coping methods were at this time.**

Not effective at all ***Completely effective***

0 10 20 30 40 50 60 70 80 90 100

5. **How satisfied were you with your overall performance on this task?**

Not satisfied at all ***Extremely satisfied***

0 10 20 30 40 50 60 70 80 90 100

6. **How would you rate this specific experience in terms of previous breathing apparatus tasks?**

One of the easiest I have ever done ***Most severe task I have ever done***

0 10 20 30 40 50 60 70 80 90 100

BORG SCALE

Please circle the response below that most accurately describes the effort required to complete the BA you have described:

6 – 20% effort

7 – 30% effort – very, very light

8 – 40% effort

9 – 50% effort – very light – gentle walking

10 – 55% effort

11 – 60% effort – fairly light

12 – 65% effort

13 – 70% effort – somewhat hard – steady pace

14 – 75% effort

15 – 80% effort – hard

16 – 85% effort

17 – 90% effort – very hard

18 – 95% effort

19 – 100% effort

20 – Exhaustion

WAYS OF COPING QUESTIONNAIRE

Please read each item below and indicate, by using the following rating scale, to what extent you used it in the situation you have just described.
The best approach is to answer each question as honestly as possible fairly quickly.
For each question circle one of the following answers: 0 = Not used
1 = Used somewhat
2 = Used quite a bit
3 = Used a great deal

	Not used	Used Somewhat	Used quite a bit	Used a great deal
1.Just concentrated on what I had to do next – the next step.	0	1	2	3
2. I tried to analyse the problem in order to understand it better.	0	1	2	3
3. Turned to work or substitute activity to take my mind off things.	0	1	2	3
4. I felt that time would make a difference – the only thing to do was to wait.	0	1	2	3
5. Bargained or compromised to get something positive from the situation.	0	1	2	3
6. I did something which I didn't think would work, but at least I was doing something.	0	1	2	3
7. Tried to get the person responsible to change his or her mind.	0	1	2	3
8. Talked to someone to find out more about the situation.	0	1	2	3
9. Criticized or lectured myself.	0	1	2	3
10. Tried not to burn my bridges, but leave things open somewhat.	0	1	2	3
11. Hoped a miracle would happen.	0	1	2	3
12. Went along with fate; sometimes I just have bad luck.	0	1	2	3
13. Went on as if nothing had happened.	0	1	2	3
14. I tried to keep my feelings to myself	0	1	2	3
15. Looked for the silver lining, so to speak; tried to look on the bright side of things.	0	1	2	3
16. Slept more than usual.	0	1	2	3
17. I expressed anger to the person(s) who caused the problem.	0	1	2	3
18. Accepted sympathy and	0	1	2	3

understanding from someone.				
19. I told myself things that helped me to feel better.	0	1	2	3
20. I was inspired to do something creative.	0	1	2	3
21. Tried to forget the whole thing.	0	1	2	3
22. I got professional help.	0	1	2	3
23. Changed or grew as a person in a good way.	0	1	2	3
24. I waited to see what would happen before doing anything.	0	1	2	3
25. I apologized or did something to make up.	0	1	2	3
26. I made a plan of action and followed it.	0	1	2	3
27. I accepted the next best thing to what I wanted.	0	1	2	3
28. I let my feelings out somehow.	0	1	2	3
29. Realized I brought the problem on myself.	0	1	2	3
30. I came out of the experience better than when I went in.	0	1	2	3
31. Talked to someone who could do something concrete about the problem.	0	1	2	3
32. Got away from it for a while; tried to rest or take a vacation.	0	1	2	3
33. Tried to make myself feel better by eating, drinking, smoking, using drugs or medication, etc.	0	1	2	3
34. Took a big chance or did something very risky.	0	1	2	3
35. I tried not to act too hastily or follow my first hunch.	0	1	2	3
36. Found new faith.	0	1	2	3
37. Maintained my pride and kept a stiff upper lip.	0	1	2	3
38. Rediscovered what is important in life.	0	1	2	3
39. Changed something so things would turn out all right.	0	1	2	3
40. Avoided being with people in general.	0	1	2	3
41. Didn’t let it get to me; refused to think too much about it.	0	1	2	3
42. I asked a relative or friend I respected for advice.	0	1	2	3
43. Kept others from knowing how bad	0	1	2	3

things were.				
44. Made light of the situation; refused to get too serious about it.	0	1	2	3
45. Talked to someone about how I was feeling.	0	1	2	3
46. Stood my ground and fought for what I wanted.	0	1	2	3
47. Took it out on other people.	0	1	2	3
48. Drew on my past experiences; I was in a similar situation before.	0	1	2	3
49. I knew what had to be done, so I doubled my efforts to make things work.	0	1	2	3
50. Refused to believe that it had happened.	0	1	2	3
51. I made a promise to myself that things would be different next time.	0	1	2	3
52. Came up with a couple of different solutions to the problem.	0	1	2	3
53. Accepted it, since nothing could be done.	0	1	2	3
54. I tried to keep my feelings from interfering with other things too much.	0	1	2	3
55. Wished that I could change what had happened or how I felt.	0	1	2	3
56. I changed something about myself.	0	1	2	3
57. I daydreamed or imagined a better time or place than the one I was in.	0	1	2	3
58. Wished that the situation would go away or somehow be over with.	0	1	2	3
59. Had fantasies or wishes about how things might turn out.	0	1	2	3
60. I prayed.	0	1	2	3
61. I prepared myself for the worst.	0	1	2	3
62. I went over in my mind what I would say or do.	0	1	2	3
63. I thought about how a person I admire would handle this situation and used that as a model.	0	1	2	3
64. I tried to see things from the other person's point of view.	0	1	2	3
65. I reminded myself how much worse things could be.	0	1	2	3
66. I jogged or exercised.	0	1	2	3

END OF BOOKLET

APPENDIX E

Longitudinal study means and standard deviations

Self-reported means (and standard deviations) of the four subjective measures of performance reported by firefighters during each stage of data collection over a 12 month period

	Data Collection Stage				
	November (1)	**December (2)**	**Jan-March (3)**	**April – June (4)**	**June – Sept. (5)**
Control over task (CT)	62 (17)	65 (14)	71 (18)	60 (18)	78 (9)
Coping effectiveness (CE)	68 (17)	68 (19)	81 (9)	65 (10)	80 (11)
Task severity (TS)	67 (30)	69 (16)	59 (20)	76 (15)	68 (23)
Performance satisfaction (SP)	63 (28)	67 (24)	81 (7)	71 (18)	82 (11)

Self-reported means and (standard deviations) of eight coping strategies reported by firefighters during each stage of data collection over a 12 month period, as measured by the Ways of Coping Checklist (WOC).

	PFC	**WT**	**DET**	**SOCS**	**FPOS**	**SBLA**	**KTS**	**TRED**
November (1)	1.47 (0.39)	1.00 (0.53)	0.67 (0.55)	1.04 (0.56)	1.04 (0.65)	1.23 (0.73)	0.71 (0.62)	1.11 (0.59)
December (2)	1.05 (0.56)	0.67 (0.52)	0.58 (0.40)	0.98 (0.61)	0.96 (0.72)	1.17 (0.72)	0.72 (0.60)	0.67 (0.65)
Jan-March (3)	1.12 (0.39)	0.66 (0.51)	0.83 (0.79)	0.88 (0.50)	0.68 (0.51)	0.90 (0.81)	0.67 (0.43)	0.60 (0.56)
April – June (4)	1.10 (0.51)	0.35 (0.41)	0.21 (0.21	0.75 (0.38)	0.75 (0.35)	1.25 (0.96)	0.17 (0.33)	0.61 (0.45)
June – Sept (5)	1.74 (0.37)	1.13 (0.75)	1.11 (0.68)	1.31 (0.47)	1.42 (0.68)	1.34 (0.40)	1.22 (0.87)	1.28 (0.61)

Note: PFC=Problem focused coping; WT= wishful thinking; DET = detachment; SOCS = Social support; FPOS = focusing upon the positive; SBLA = self-blame; KTS = Keeping things to self; TRED = tension reduction

APPENDIX F

SCBA exercises (search and rescue, guideline and live firefighting) data collection booklet

Participant Information Booklet

PARTICIPANT ID...

RANK...

AGE (YYMM)..

YEARS OF SERVICE (yymm)..

PSS-10 COMPLETED ☐

BASELINE HEART RATE..

BASELINE BLOOD PRESURE..

BASELINE BOND-LADER COMPLETED ☐

PARTICIPANT ID (please circle)

F1 F2 F3 F4 G1 G2 G3 G4 G5 G6 G7 G8 G9 G10

DAY 1 – TASK 1: GL FS LF

PRE – EXERCISE	POST – EXERCISE
TIME OF ENTRY: AIR PRESSURE (BAR):	TIME OF EXIT: AIR PRESSURE (BAR):
Blood pressure.............................. ☐	Borg scale.................................... ☐
Heart rate...................................... ☐	Blood pressure............................. ☐
Bond –Lader VAS.......................... ☐	Heart rate...................................... ☐
	NASA-TLX VAS............................ ☐
	Bond – Lader VAS......................... ☐

COMMENTS

RESEARCHER INITIALS	

PARTICIPANT ID (please circle)

F1 F2 F3 F4 G1 G2 G3 G4 G5 G6 G7 G8 G9 G10

DAY 1 – TASK 2: **GL** **FS** **FF**

<table>
<tr>
<td>

<u>PRE – EXERCISE</u>

TIME OF ENTRY:
AIR PRESSURE (BAR):

Blood pressure............................... ☐

Heart rate...................................... ☐

Bond –Lader VAS.......................... ☐

</td>
<td>

<u>POST – EXERCISE</u>

TIME OF EXIT:
AIR PRESSURE (BAR):

Borg scale...................................... ☐

Blood pressure............................. ☐

Heart rate...................................... ☐

NASA-TLX VAS............................ ☐

Bond – Lader VAS.......................... ☐

</td>
</tr>
</table>

COMMENTS

RESEARCHER INITIALS	

PARTICIPANT ID (please circle) F1 F2 F3 F4 G1 G2 G3 G4 G5 G6 G7 G8 G9 G10	
DAY 2 – TASK 1: GL FS FF	
<u>PRE – EXERCISE</u> TIME OF ENTRY: AIR PRESSURE (BAR): Blood pressure..............................☐ Heart rate......................................☐ Bond –Lader VAS..........................☐	<u>POST – EXERCISE</u> TIME OF EXIT: AIR PRESSURE (BAR): Borg scale.....................................☐ Blood pressure.............................☐ Heart rate......................................☐ NASA-TLX VAS.............................☐ Bond – Lader VAS..........................☐
COMMENTS	
RESEARCHER INITIALS	

APPENDIX G

Incident command participant booklet

Participant information

Participant ID....................................

Current Role (please circle)......FF..........CM........WMA.......WMB......SM.........GM.....

Time in current role (YY- MM) ....

Years of operational service (YY-MM)................................

Age (YY-MM).......................................

Sex....................................

I confirm I have read and fully understood the participant ☐ information and signed an informed consent form (please tick)

Primary role during task (i.e. ECO, incident commander, etc) ………………………

PRE - TASK

A number of statements which people have used to describe themselves are given below. Read each statement then mark on the line at the most appropriate point to indicate <u>how you feel right now, at this moment</u>

I feel anxious*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel calm

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel tense

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I am upset

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel relaxed

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel content

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel worried

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel stressed*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel happy*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

POST - TASK

A number of statements which people have used to describe themselves are given below. Read each statement then mark on the line at the most appropriate point to indicate

how you feel right now, at this moment

I feel anxious*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel calm

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel tense

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I am upset

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel relaxed

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel content

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel worried

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel stressed*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

I feel happy*

0 10 20 30 40 50 60 70 80 90 100

not at all very much

POST - TASK

Please mark each line at the point which matches your experience of the test you have just completed

A) **MENTAL DEMAND** – How much mental demand and perceptual activity was required (thinking, deciding, calculating, remembering, looking etc)? Was your task easy or demanding, simple or complex?

Low |___|___|___|___|___|___|___|___|___|___| High

B) **PHYSICAL DEMAND** – How much physical activity was required (pulling, turning, controlling activating etc)? Was your task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

Low |___|___|___|___|___|___|___|___|___|___| High

C) **TEMPORAL DEMAND** – How much time pressure did you feel due to the rate of the task? Was the pace slow and leisurely or rapid and frantic?

Low |___|___|___|___|___|___|___|___|___|___| High

D) **EFFORT** – How hard did you have to work, mentally and physically, to achieve your level of performance?

Low |___|___|___|___|___|___|___|___|___|___| High

E) **PERFORMANCE** – How successful do you think you were in performing the tests? How satisfied were you with your performance ?

Low |___|___|___|___|___|___|___|___|___|___| High

F) **FRUSTRATION** – How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel?

Low |___|___|___|___|___|___|___|___|___|___| High

END OF BOOKLET

THANK YOU FOR YOUR TIME

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